

**THE DEVELOPMENT OF A CONCEPT PLAN FOR THE ECOLOGICAL
RESTORATION OF QUAIL ISLAND (*OTAMAHUA*)**

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Frontispiece. Naturally regenerating *Hebe salicifolia* and *Pittosporum tenuifolium* seedlings beneath a planted canopy of native broadleaves, situated on the east coast of Quail Island.

"At first, when any of them is liberated and compelled suddenly to stand up and turn his neck around and walk towards the light he will suffer sharp pains;...will he not fancy that the shadows which he formerly saw are truer than the objects which are now shown to him." (Plato, The Republic, Book VII pp.254-255 Translation by B.Jowett, 1988).

Let's say the visible forest is the shadow of its immutable form, cast from Plato's world of perfect ideas. When the light behind this form is extinguished, it is the landscape that whispers its existence and reason that deduces the shape of its former shadow (*cf* Gaarder, 1994 & Weaver, 1994)

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Abstract

It is deduced that a sub-humid, maritime-cool temperate, mixed broadleaf-podocarp forest probably covered most of Quail Island in pre-settlement times. It is likely that the island was deforested by early Polynesian settlers. The occurrence of forest precursors, the presence of forest remnants in environmentally analogous sites elsewhere, as well as the healthy state of natives planted in 1983 are indicative that forest recovery processes are still active and Quail Island retains a forest environment.

In the development of a restoration philosophy for Quail Island, a values system is proposed that enables all species to be viewed in terms of their functional role in the contemporary ecosystem. The perceived restoration goal is to both reinitiate and speed up the native forest recovery processes on Quail Island.

The main environmental restoration constraints are the presence of rabbits and mustelids. A social impact assessment scoping exercise revealed near-universal support for the concept, although the Department of Conservation is divided over support for the concept and this poses the main cultural constraint. The concerns of the principal stakeholders are mediated through the modern ecotourism paradigm within the framework of a proposed variant of the Biosphere Reserve concept.

The process of restoration should be guided through a Medium Interference Management strategy that aims to mimic forest recovery processes through the development of strategically placed "forest cells". Lists of species for selection are based on those that are present in sites environmentally analogous to Quail Island. Scrubby woody cover could be attained in 10-15 years and a low forest canopy could be achieved in 20-25 years. Eight locally extinct forest bird species are suggested for translocation along with one coastal species. Four species of reptiles are also considered. A monitoring scheme is suggested to gauge success and progress.

Chapter 1: Introduction

1.0 Aims

The aim of this thesis is to develop a concept plan for the ecological restoration of Quail Island. The notion of a concept plan was first introduced by Norton (1992) and represents a new approach to the development of restoration projects. A concept plan can be defined as a set of guidelines on how to achieve a particular goal. It differs from a management plan which is a set of instructions that apply these guidelines. An ecological restoration concept plan is a set of guidelines that take into account the physical, biotic and cultural environment and if followed ensure that the objective is realised.

As the project potentially covers a wide variety of topics, given the time constraints it was impossible to deal with all aspects and to investigate every one in depth. For this reason the evidence collected was qualitative and restricted to the most important considerations that lie within the bounds of the discipline of environmental science. The evidence presented is based on field reconnaissance, literature reviews, consultation with experts and interviews with representatives of stakeholder community groups. Economic analysis, although essential for the management of any conservation project was not studied. This has been left for future research. Despite this short coming, I believe the prescriptions developed form a substantial part of the basis for the development of a management plan for the ecological restoration of Quail Island.

In this chapter I provide some initial background to the natural and cultural landscape of Quail Island and why it was considered for ecological restoration. This is followed by definitions of "ecological restoration" and "restoration ecology". The chapter concludes with an outline of the structure of this thesis.

1.1 Background to Quail Island

Quail Island is a rather bare, low-lying inshore island located at the head of Lyttelton Harbour on Banks Peninsula (Figure 1.1). The island covers an area of approximately 86 hectares (Jackson, 1990). At extreme low tide mudflats connect the island to the mainland. It is climatically and edaphically similar to the mainland with low rainfall (600-800mm p/a), moderate temperatures (mean annual temp 12°C) and semi-fertile soils. The island is characterised by a rolling central plateau, bordered by sheer cliffs facing the north east, with steep to very steep slopes and narrow shelly beaches around most of the island (Sisson, 1976).

In pre-settlement times almost all of the Lyttelton Harbour Basin was covered in mixed podocarp broadleaf forest. Only the most exposed headlands and ridges were not forested but supported a lowlying coastal and subalpine scrub respectively (Thomas, 1989; Lilley, 1990; Lord, 1990; 1991; Wilson, 1992a; Burrows, 1994; cf Petrie, 1963).

Although the exact nature of the original vegetation of Quail Island is unknown, it is likely that it supported a maritime variant of this forest (Chapter 4.2.2). The island's original forests were probably cleared by early Polynesian settlers for agricultural and strategic purposes (Chapter 4.1.1). At the time of the European arrival the island's vegetation was dominated by silver tussock (*Poa cita*) grassland with matagouri scrub (*Discaria toumatou*) and cabbage trees (*Cordyline australis*).

Quail Island was acquired from the Ngai Tahu by the Crown in 1850. From this time onwards it was periodically farmed, although it was also used as a quarantine station and a prison. In 1976 the island was gazetted a Recreation Reserve and administered by the then Department of Lands and Survey. It is now part of the Conservation Estate and controlled by the Department of Conservation (DoC) in Canterbury (Jackson, 1990). The island remains of great cultural and spiritual importance to the Ngai Tahu of Rapaki and they retain Mana Whenua over it (Chapter 5.5).

Quail Island has two sheltered beaches and it is used frequently during the spring and

summer months as a popular site for picnics, swimming and boating. It is also furnished with a good visitor infrastructure and a system of tracks that traverses the island (Figure 1.2). The current vegetation is dominated by exotic grassland and shelter trees, however there remain large areas of native scrubland with some very small areas of second growth broadleaf forest. The island has low wildlife values, playing host to the usual coastal assembly of waders and gulls as well as the mixed exotic and indigenous pastoral and scrub birds. It supports a very large population of rabbits along with mustelids, hedgehog and rodents. A revegetation project was started in 1983 (Jackson,1990) and succeeded in establishing a significant stand of forest trees. The project was however abandoned in the early stages due to huge seedling losses caused by rabbit browsing and summer drought (Chapter 3).

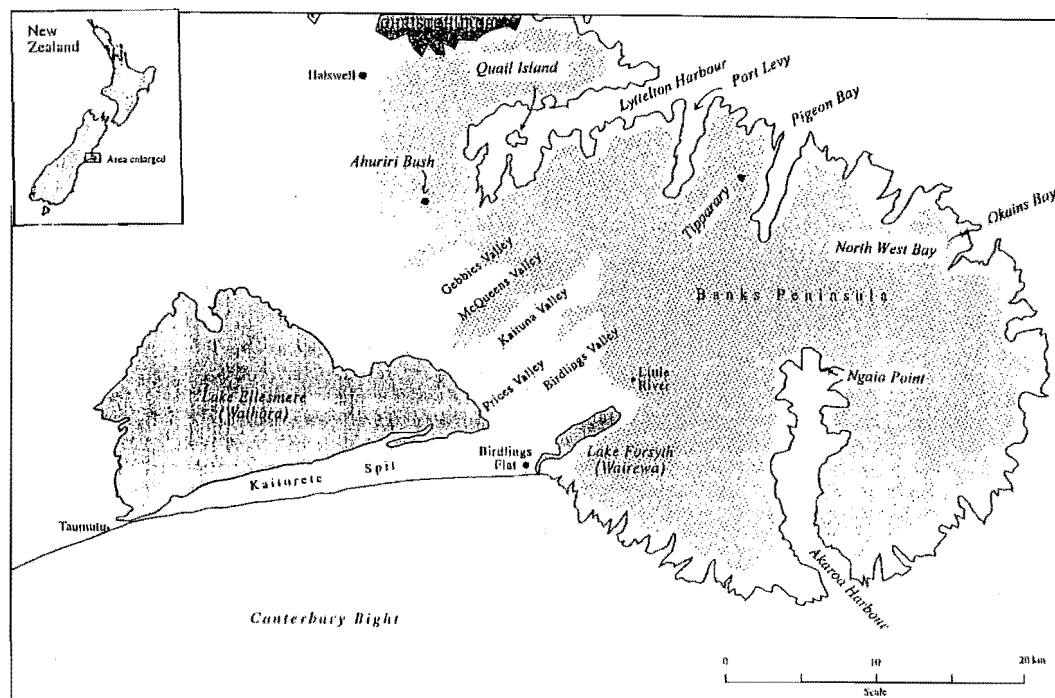


Figure 1.1 Location Map of Quail Island, Banks Peninsula.

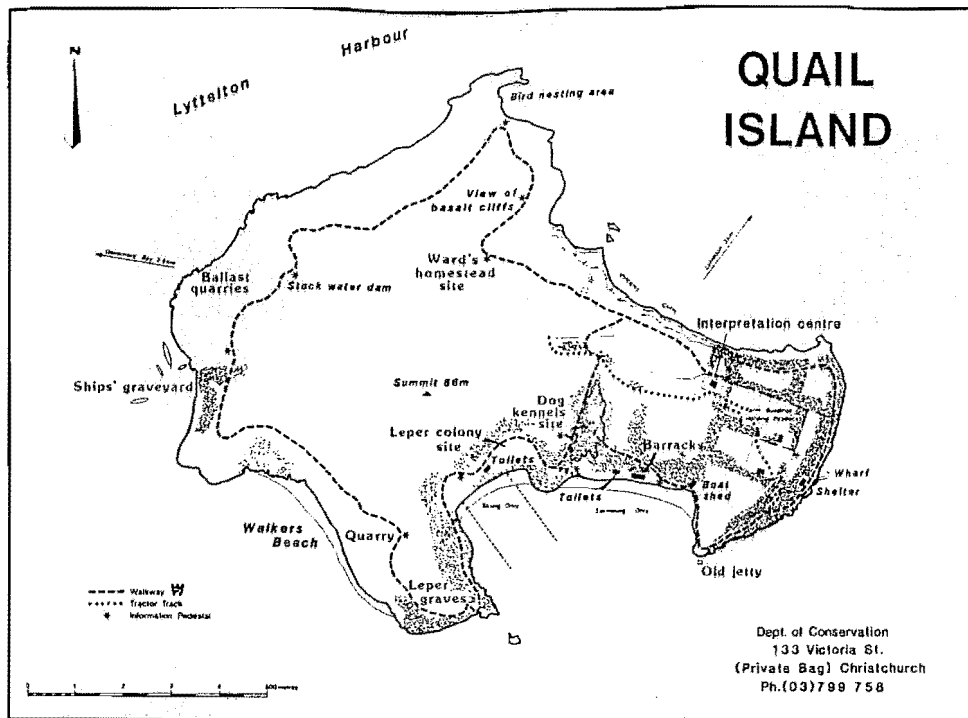


Figure 1.2 Quail Island as a Recreation Reserve (after Jackson,1990 p.vi).

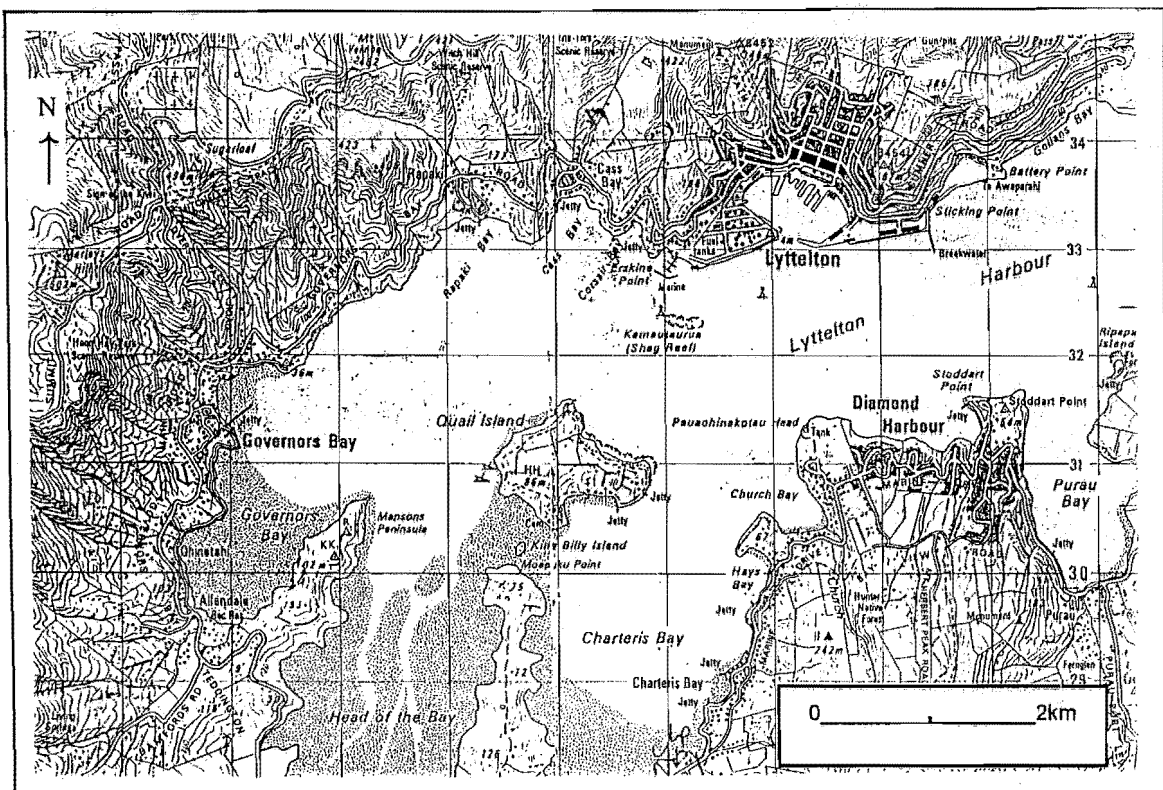


Figure 1.3 Head of the Bay, Lyttelton Harbour (after NZMS 260 Lincoln).

1.2 Why consider Quail Island for ecological restoration?

The loss of much of New Zealand's biodiversity since human settlement can be attributed to two main causes: the clearance of most of the productive fertile lowland podocarp forests and the introduction of foreign organisms such as mammalian predators and disease. The extent to which one factor or the other plays is debatable, although it is conceivable that loss of habitat alone was the principal cause of the extinction of those species that had specialised habitat requirements (Bell, 1991).

Currently most threatened species are confined to protected natural areas. These areas were usually of low fertility and confined to upland and alpine areas and they were originally reserved because they were considered to have little economic potential (James, 1990; O'Connor *et al*, 1990; Park, 1995). Despite concerted efforts to maintain populations of threatened native organisms, especially birds, on the conservation estate, their numbers continue to decline (Department of Conservation, 1995). At present predation is blamed for the continual decline. However from studies of the saddleback (*Philesturnus carunculatus*) (Craig, 1994) and the yellowhead (*Mohoua ocrecephala*) (Elliot, 1990), it is suggested that the fall in numbers may be due in part to the low productivity of the forests in which they are confined. Low productivity may lead to low species fecundity and a reduced ability to offset predation (*cf* Brockie, 1992). It may be possible that if productive lowland forest habitat could be restored, an equilibrium between predators and threatened avifauna could be established.

Offshore islands that lie beyond the range of exotic mammalian predators are usually regarded as the only remaining hope for New Zealand's threatened species (Department of Conservation, 1995). While these islands offer protection from predation they are not always representative of the range of conditions experienced on the mainland (Meurk and Blaschke, 1990). Translocated mainland species are often placed into less than optimal habitat, which reduces their fecundity and chances of survival (Craig, 1994). The use of zoos, botanic gardens and islands as wildlife refuges is categorised

as "*ex situ* conservation". Owing to the many disadvantages associated with the conservation of an organism outside its natural habitat, the Rio de Janeiro Biodiversity Convention urged a shift to the conservation of the ecosystem of a specific organism, or *in situ* conservation (Norton, 1993). In accordance with this recommendation, "mainland habitat islands" (Norton, 1993) and ecologically restored inshore islands, such as Quail Island (Muerk and Blaschke, 1990), have been suggested as alternatives.

Ideal inshore islands are those further enough away from the mainland to resist invasion by introduced mammals but close enough to have a more favourable "continental" climate and zonal soils (Muerk and Blaschke, 1990; Towns *et al*, 1990; Wright and Cameron, 1990). Inshore islands are favourable for conservation because they are climatically and edaphically very similar to the mainland and can potentially provide more productive representative habitat for indigenous species. However many such islands were sought after for settlement and agricultural purposes by both Polynesian and European arrivals and were consequently stripped of their forests (Muerk and Blaschke, 1990). With the subsidence in the farming sector in recent years many of these islands have been deserted and taken over as reserves. In many instances their conservation potential can only be realised through large scale forest restoration, such as practised on Tiritiri Matangi Island in the Hauraki Gulf and Mana Island near Wellington.

Bearing in mind the above statements, the ecological restoration of forest on Quail Island would serve three general objectives. Firstly it would extend the area of maritime lowland forest of Banks Peninsula, providing productive habitat for threatened and locally extinct avifauna. In this environment such species may have a better chance of survival than in existing forest reserves. Secondly it was observed in Westland that there is an internal seasonal migration of birds between upland and lowland forest areas (*cf* Wilson *et al*, 1988). It is possible that the same seasonal movements once occurred in the forests of Banks Peninsula. The restoration of forest on Quail Island may provide lowland components to the reserves system in the Mt

Herbert and Port Hills Ecological Districts, thus facilitating the movement and spread of propagules between protected natural areas. Thirdly as Quail Island is accessible to the public it could provide many opportunities for conservation advocacy.

1.3 Definitions of ecological restoration and restoration ecology.

Before describing the proposed research into the development of a concept plan it is pertinent to clarify the terms "ecological restoration" and "restoration ecology". There is no universally accepted definition of ecological restoration and consequently there has been considerable confusion over the setting of restoration goals and success criteria. However the definition considered to be most appropriate for the purposes of this thesis is that developed by Atkinson (1988, 1995 (cited in Miskelly, 1995)) and later refined by Norton (1996). Thus ecological restoration can be defined as *"..the active intervention and management to restore or partially restore biotic communities, both their plants and animals, and the associated physical environment as fully functioning and sustainable systems with a predominance of indigenous species."*

Ecological restoration encompasses various levels of environmental protection and enhancement, all of which can be viewed as a continuum. For example with attempts to restore highly degraded sites, such as mine tailings, at one extreme, to the extirpation of exotic pest species in near-pristine areas, such as the removal of rats from Maud Island, at the other (Hobbs and Norton, 1996). In many ways conservation activity in New Zealand is restorative and the goals in ecological restoration and conservation are synonymous. The restoration continuum may be divided up using four basic restoration based activities described by Aronson *et al* (1993a). These are as follows: Restoration *senso stricto* and *senso lato*, followed by *rehabilitation* or *reclamation* and finally *reallocation*.

Restoration *senso stricto* refers to the reassembly of some predefined, usually historic species inventory. On the other hand *restoration senso lato* seeks to arrest the

degradation and redirect the disturbed ecosystem into a trajectory resembling that which prevailed before the disturbance event. *Rehabilitation* involves the repair of damaged or blocked ecosystems, applying management techniques that will "jump start" the natural recovery processes. *Reallocation* represents an unnatural situation of perpetually interrupted succession (Jarrel, 1990 cited in Aronson *et al*, 1993a) such as a garden or a wheatfield. The Quail Island project could be described as lying somewhere between *rehabilitation* and *restoration sensu lato* (Chapter 2.5)

The term restoration ecology was coined by W.R. Jordan III in 1988. It is used to define the practice of restoring ecological systems "*..as a way of raising basic questions and testing fundamental hypotheses about communities and ecosystems being restored..*" Such a process has also been termed "synthetic ecology" by the same author. Ecological restoration provides opportunities to test ecological theories of ecosystem assemblage while practising conservation, although this is not the expressed intention.

1.4 Thesis structure and rationale

Although the terms restoration goal, restoration vision and restoration process are frequently used they are largely ill-defined. Before commencing it is important to clarify what is meant by these terms and the way they are used in this text. The vision is a synthesis of restoration potentials and constraints which constitutes a realistic target, for example, an old growth forest. The goal is the ideological basis from which a project to restore this ecosystem is launched and directed, it is therefore strongly influenced by the perception of the vision. The process is the practical application of the ideology contained in the goal or the means taken to materialise the vision. A way to illustrate these definitions is through the use a simile. The goal could be represented by an archer, the vision could be regarded as his target and the arrow's flight path could be thought of as the process.

The setting of realistic goals is central to the success of restoration projects (Atkinson,

1990; Norton,1991). Goals are formulated from a predetermined paradigm, which is conceived through a system of tenets or philosophy. In Chapter 2, the prevailing conservation philosophy held by the Department of Conservation is reviewed. At the core of conservation practice in New Zealand is the unrealistic desire to restore a pre-colonial condition. A more pragmatic restoration position is developed for Quail Island. Central to the Quail Island philosophy is a sense of duty to provide habitat for pre-colonial species while allowing nature to sort out the final ecosystem composition, structure and function. The application of this view to this thesis is based on the theories of community assembly developed by Keddy (1992) and Weiher & Keddy (1995). Briefly, community assembly can be thought of as engaging a series of environmental filters which sift out functional groups of species from a regional pool of biodiversity. Environmental filters can be thought any biotic or abiotic factor that inhibits the establishment of a plant or animal at a specific site. The final species composition will depend on what species are able to pass through these filters. The full set of filters for a site can be summarised as habitat for specific genotypes (*cf* Keddy, 1992). Species pools should be made up of species that are considered ecologically appropriate to the prevailing conditions on Quail Island. Species should be drawn from "restoration reference states"(Hobbs and Norton,1996), that is from environmentally analogous but forested sites.

In Chapter 3, the physical and natural environment of Quail Island is described in terms of environmental filters. Firstly the island is posited in an appropriate bioclimatic zone, this facilitates the location of environmentally analogous reference ecosystems. Secondly the local landscape, vegetation and avifauna relationships are investigated. This consists of a review of the island's abiotic and biotic values. As the goal is to reinitiate and accelerate forest recovery processes through the mimicry of natural recovery processes, the usual vegetation change sequences occurring both on the island and on environmentally analogous sites are examined.

The restoration reference states for Quail Island are described in Chapter 4. They are comprised of sites environmentally analogous to Quail Island supporting stands of

remnant old growth, second growth forest and vegetation transitional to forest. With the use of the literature, the character of the vegetation and avifauna for each state from pre-settlement and pre-colonial periods is described where possible. The reptile fauna is described where possible. These states serve to indicate ecologically appropriate locally extinct and threatened species for translocation, while highlighting the gaps left in the ecosystem through extinctions.

Conservation projects are dependent on public support and also have significant social impacts. In Chapter 5, the principal stakeholders are identified and the main concerns associated with this project are established. In Chapter 6, the role of the human community could play in the restoration project is discussed.

In Chapter 7, the likely abiotic, biotic and social factors that may constrain the project are discussed. This leads onto the restoration vision statement; this represents a synthesis of restoration potentials and constraints which is used to provide a realistic target for the restoration process.

In Chapter 8 the restoration goal is stated and an appropriate restoration process for Quail Island is suggested. This introduces a medium interference mangement strategy that aims to meet the requirements set out in the restoration goal statement. Lists of plants to be placed into species pools ("forest cells") as well as a list of avifauna for translocation are presented. In order to gauge the progress and success of the project a monitoring programme is suggested in Chapter 9. In the final chapter conclusions are drawn and the main findings summarised .

Chapter 2:

The Development of a Restoration Philosophy for Quail Island

2.0 Introduction

In order to perform ecological restoration and determine the success of projects it is essential to first define realistic goals (Norton, 1991). Goals are formulated from a predetermined paradigm, which is conceived through a system of tenets or philosophy. Goals in conservation biology are based on changeable functional postulates (working assumptions derived from observation) and normative postulates (values statements) of conservation practice (Soulé, 1985). Conservation activity in New Zealand is restorative and the goals in ecological restoration and conservation practice are often synonymous (Chapter 1.3). Central to New Zealand conservation practice is the preservation of what is considered natural, representative and indigenous. Naturalness is defined as a state in ecosystems characterised by an absence of human influence. It is often determined by the presettlement and/or pre-colonial 1840 datum (O'Connor *et al*, 1990). "Indigenusness" is perceived in the same way and refers to all species present before 1840 (Genet *et al*, in prep). It has been the central aim of the DoC to set up a comprehensive system of reserves that represents the full range of natural ecosystems.

In this chapter I question the validity of this tenet. In section 2.2 I examine some of the main practical, ecological and philosophical problems associated with the application of the naturalness paradigm in restoration practice. In the philosophical discussion I propose that the naturalness paradigm perpetuates the human-nature dualism, which is believed to be the cause of the environmental crisis. I discuss two means by which the duality could be dissolved, that is from an ethical and a postmodern approach. It is here I introduce the concept of the "contemporary forest ecosystem" as a blend of naturalised post-colonial and pre-colonial species. This constitutes the backdrop for a realistic restoration vision for Quail Island which is discussed in section 2.4.

2.1 Naturalness

Naturalness is seen as a continuum stretching from natural to semi-natural through to anthropocentric systems. Naturalness is widely assessed through the levels of departure from the 1840 datum, usually measured in terms of the proportion of indigenous species to exotic species. Running parallel to this is a corresponding valuation continuum, that values natural areas (O'Connor *et al.* 1990) and pre-colonial species more highly than the others. In other words conservation and restoration projects in New Zealand operate under the overarching tenet of what is "old" (pre-colonial) is "natural", what is "natural" is "indigenous" and what is "indigenous" is "good". This sort of valuation system is problematic for a number of practical, ecological and philosophical reasons and may work to constrain conservation activities (Soulé, 1990; Westman, 1990; Bratton, 1992; Hobbs and Norton, 1996; Genet *et al.*, in prep).

2.2 Problems with the valuation system

Impracticalities

New Zealand restoration objectives are usually based on Atkinson's (1988,1995) definitions which attempt to reproduce some pre-colonial ecosystem. This can be categorized as *restoration senso stricto* (Chapter 1.3). The goals of this form of restoration are usually considered unrealistic for a number of reasons. Firstly even if the composition of these systems could be fully known they are invariably impossible to restore. This is due to the extinction of species and the advent of others and a contemporary environment in which antecedent conditions no longer exist (Leopold, 1934 cited in Meine, 1988; Simberloff, 1990; Hobbs and Norton, 1996; Hunter, 1996; Norton, 1996). Secondly owing to the extent of human influence and the concomitant pervasion of exotic species it is doubtful that there are any remaining pristine natural areas left in New Zealand (Mark,1984; O'Connor *et al.*,1990); in other words "naturalness" is anachronistic (Soulé,1990). This means there are no real pre-colonial

extant reference states left for restoration or monitoring. Thirdly, the creation of a pre-colonial habitat would entail the extirpation of all post-colonial species from all natural areas and restorations. In the light of the pervasiveness of these species this would seem unfeasible at present and some would say both undesirable and irrational (Westman, 1990). Despite this many past and current restoration projects continue to set themselves impossible goals and success criteria that can never be met (*cf* Bradshaw, 1987).

Through the natural values system, restoration projects are often designed to be "museum pieces" and ideally post-colonial species should be extirpated for the sake of authenticity and the maximisation of pre-colonial biodiversity. This stance is usually held but impractical to instigate. This has led to the toleration of certain post colonial species resulting in a continuum of species preferences (Figure 2.1). Those species that facilitate the attainment of the restoration goal may be considered "benign" and they are located towards the left hand side. Those species that were introduced and have a disruptive effect are considered "malicious" and they are found towards the right hand end of the continuum. Exceptions to this apparent practice are when indigenous species are outside of their range or they are a threat to a higher priority native species. Those at the "benign" end are considered the most "natural" and hence the most "valuable".



Figure.2.1 Continuum of species prioritised for preservation and eradication from restoration islands and mainland habitat islands.

Two examples illustrate many of the points already discussed and raise others which are elaborated on in the next section. In the Orongorongo Forest the self introduced silvereye (*Zosterops lateralis*) may compete with native honey eaters and may be partly responsible for their decline (Brockie, 1990). In order to restore "naturalness" to this forest community it would be necessary but impractical to eradicate this bird. Furthermore it is difficult to know how to value this bird. The silvereye, not unlike

many of New Zealand's pre-colonial avifauna (Heather, 1963), arrived from Australia in 1850 and became extremely successful (Falla *et al*, 1972). It is uncertain whether its success can be attributed to anthropogenic habitat modification or whether it would have established anyway. At any rate it is illustrative of the difficulty in deciding whether a species fits into the criteria of indigeneness set by the 1840 datum (O'Connor *et al*, 1990). Secondly Tiritiri Matangi Island supports a flock of eastern rosellas (*Platycerus eximius*) which do not appear to have adverse effects on other species. However they could be thought to detract from the restoration's "authenticity" and for this reason they should also be extirpated. This however would be unlikely owing to the strong affinity local Auckland people have for this attractive bird.

Ecological Problems

The overall impracticality of eradicating exotics has led to an integration of indigenous and exotic biota creating a contemporary hybrid biota. Of central importance to this dissertation is the role of exotic species in facilitating the recovery of predominantly pre-colonial native forest. It is now widely accepted that on the Port Hills surrounding Quail Island, native bracken (*Pteridium aquilium*) with the introduced weeds of gorse (*Ulex europaeus*), broom (*Cytisus scoparius*) and elder (*Sambucus nigra*) form an old field vegetational change sequence leading to a native mahoe (*Melicope ramiflora*) dominated broadleaf-podocarp forest. Williams (1983), McCracken (1993) and Wilson (1994a) have demonstrated that gorse can act as a nurse species for native forest seedlings substituting for the slower growing and persistent kanuka (*Kunzea ericoides*) stands which can remain for up to 100 years before there is a transition to forest. This sequence is common throughout the region and is also occurring in isolated areas on Quail Island (Chapter 3. Figures 3.3). Native seed is dispersed from forest fragments into this weedy matrix by predominantly non-indigenous species such as blackbirds (*Turdus merula*), the song thrush (*T. philomelos*), starlings (*Sturnus vulgaris*), silvereyes and even the brush-tailed possum (*Trichosurus vulpecula*) (Roger Dungan, pers com). The resulting forest system is neither wholly indigenous nor completely exotic, but a blend of both. It is postulated here that even though the species

composition of this contemporary wild forest is very different from the pre-colonial forest ecosystem, it should be structurally and functionally similar. This is because ecosystem structure and function are determined by the environmental filters which operate on exotic and indigenous species alike (Ewel, 1986; Ewel *et al*, 1991).

Although it is still contentious, evidence suggests that post-colonial vertebrate species in many native forest locations may also be in a state of equilibrium with pre-colonial species. The extirpation of certain exotic species may in some cases upset this natural balance resulting in further degradation. For example the removal of exotic frugivorous birds from the Ahuriri Bush, Banks Peninsula would seriously impair native seed dispersal (Burrows, 1994). Rats in some forests constitute the main food of stoats. The removal of rats in some forests may mean that stoats either respond by reducing their numbers or by switching to another prey, which can often be native birds (Murphy and Bradfield, 1992).

Bremner *et al* (1984) assert that introduced mammals have had a devastating effect on invertebrate populations and driven many species to extinction. However Rickard (1996) speculates that the major wave of invertebrate extinctions caused by predation may be over and a state of balance has been attained. Nevertheless Brockie (1990) surmises that in the Orongorongo Forest equilibrium cannot occur until all the individuals unable to cope with predation and herbivory are eliminated by natural selection. Because of control programmes it is impossible to tell whether these animals will ever reach some sort of dynamic equilibrium with the forest or the prevailing meta-stable state (Brockie, 1990).

Philosophical Problems: The human-nature dualism

The above examples are illustrative of values based or normative postulates of conservation thinking. Furthermore, the separation of what is natural from what is unnatural and indigenous from exotic is illustrative of the human nature dualism that divorces society from nature. This is widely believed to be one of the principal causes of ecological unsustainability, which is in turn believed to be the cause of the

environmental crisis (Scott, 1986; Norton, 1987; Weaver, 1994). For conservation practice to employ the cause of the problem to solve the problem is inherently counter productive and can only constrain the conservation movement. In the following section, I discuss two possible ways of dissolving the duality and applying them to restoration and conservation.

2.3 Philosophical Solutions: An Ethical Approach

Scott (1986) attempted to dismantle the duality by assigning ethical value to nature. It was hoped that ethical restraint would become a substitute for ecological constraints of carrying capacities, which society through technology and war, is able to temporarily extend (Peet, 1993). Central to Scott's thesis was the establishment of "inherent values" for species and ecosystems. Certain values were assigned in accordance with their perceived value to the biosphere. Scott recognised that human goods are opposed to ecosystem goods and their corresponding values are in conflict (Figure 2.2). For example as smallpox ensures that natural resources are conserved by tapering the human population, it is considered to be a "moral good" for the biosphere (Scott, 1986). However, due to modern medicine, the virus is probably extinct in the wild now and as it alleviates unnecessary suffering, it is a human moral good. There is therefore a clash of values and the smallpox virus falls into into Region 'B': the area of greatest moral conflict (Figure 2.2).

Applying this model to restoration concerns, gorse may have a high ecological value due to its role in native forest regeneration on the Port Hills (Williams, 1983; McCracken, 1990; Wilson, 1994a) but a very low human value owing to the problems it causes farmers. Gorse therefore falls into Region B, the area of greatest moral conflict. Region 'A' (No moral conflict) represents an area of no conflict between the two values. Unmodified nature returns benefits both to people and to nature, and therefore it is a moral good. Destruction of nature would be both unacceptable in both human and ecological terms. In Region 'C' (Greatest moral good) environmental

intervention allows considerable human benefit but limited ecological costs and therefore it is morally acceptable to both nature and humanity (Scott, 1986).

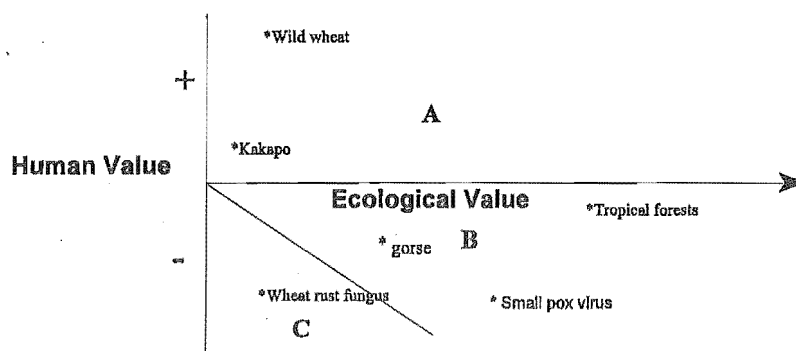


Figure 2.2 Gauging human and ecological values. After Scott (1986).

Scott's model is problematic. Firstly, as "species" and "ecosystems" are conceptual inventions not sentient beings they cannot be harmed and therefore they can have no moral rights (Gunn and Edmonds, 1986). Secondly all values systems are human inventions and can only be subjective. The so-called "inherent values" of species are based on our own ever-changing knowledge of ecosystems and autecology; that is they are based on functional postulates. For example, how we value gorse is dependent on how well we understand its functional role in the ecosystem.

Nevertheless Scott's framework is of use if we do not pretend that ecological values are anything but human perceived values for nature. In terms of overcoming the human-

nature duality it provides a conceptual framework to regard each species and ecosystem in terms of their functional role in the biosphere. It is, however, only as good as our knowledge of autecology.

A Post Modern Approach

Postmodernist thinkers believe the division between humans and nature is derived from Descartes' subject-object dualism (Weaver, 1994). Here there is an irreconcilable divide between the active subject and the passive object. The subject is creative or active while the object is passive and shaped by the subject. In Western society, nature is considered to be the passive object, while culture is thought of as the active subject. According to Heidegger, Nietzsche and Wittgenstein, Cartesian dualism is an artificial construct of language (Weaver, 1994). For example the word "tree" identifies the object and automatically excludes everything that is not a tree, that is, the "non-tree". Further, if I use the term "me" to indicate myself I automatically establish a division between everything that is "me" and "not-me"; the "not-me" is the landscape, nature or "the other". This is the concept of the autonomous self (Weaver, 1994).

Cartesian dualism can be made soluble through the switching off of language and thought, in which case one will enter a state of nihilism. At this point the subject and the object become one (Weaver, 1994). Now any action taken by me, the subject, against nature, the former object, is now action taken by myself against myself simultaneously. If I damage the other, I simultaneously damage myself. From this oneness spontaneously emerges compassion for, and a sense of belonging to the landscape; this Weaver (1994) calls "aptness". Such a state is reminiscent of the attainment of unity with the Tao which Lao tse spoke of (Lun, 1958) and nirvana in Buddhist thought (Smart, 1969 p.115). This state results in the formation of a dialectic relationship between society and nature, resulting in ecological sustainability (Weaver, 1994; cf Norton, 1987). Through this line of reasoning, society becomes part of nature. A distinction can no longer be drawn between what is natural and unnatural, indigenous and exotic and the species valuation system falls apart.

Weaver (1994) defines "indigenoussness" in terms of "aptness", or the ability to survive and maintain a viable population in a place through a dialectic and co-determinate relationship with the landscape. A species becomes non-apt or non-indigenous when it can no longer harmonize with its environment; at such a time it will inevitably become extinct. An unsustainable human society by its nature cannot be indigenous and will also eventually drive itself to extinction.

Indigenoussness can be seen as both spatially and temporally contextual (Soulé, 1990; Genet *et al*, in prep). For example, the geographical range of a species may be reduced by climate change rendering it no longer indigenous to its former range. The treeline on Banks Peninsula during the Otiran glaciation was approximately 300m asl (Thomas, 1989) while during the last millennium forest covered the full altitudinal ranges from sea level to 900m asl (Wilson, 1992a). The genus *Cocos* was present during the Tertiary but could not survive the Quaternary cooling. This suggests that in looking for that which is indigenous in modern landscapes it is necessary to look to the present and not to the past. By this line of reasoning many exotic species are well adapted to contemporary ecosystems and can be thought of as indigenous to them (Genet *et al*, in prep).

A recovering forest ecosystem can be considered as comprised of a series of transient phases or metastable states (Drake, 1990 cited in Hobbs and Norton, 1996). The components of these phases cannot necessarily be interchanged, doing so would render them ecologically inappropriate or "non-indigenous". For example phases in forest development may range from bare ground, after-fire disturbance or an erosion event, to a canopy of bracken in moist areas, or stands of silver tussock, cabbage trees and matagouri in dry areas; followed by second growth broadleaf forest and finally succeeded by a mature mixed matai-broadleaf forest. Species of each meta-stable state are indigenous to that state. For example silver tussock is indigenous to high light intensity disturbance sites but non-indigenous to the ground cover of the shady forest interior.

At this point it may be appropriate to consider the vegetation change phases holistically, where each phase in a sequence may be seen as a part of the most stable phase. For example tussock grassland can be thought of as a phase of matai-broadleaf forest development. The prevailing environmental filter will determine the most stable phase and the latter is indicative of the former.

Through the dissolution of the human-nature duality it could be argued that the environmental changes (such as the marginalisation of so many pre-colonial species) caused through colonisation are acceptable and it is no longer necessary to practise conservation. However I believe the contrary is true. The threatened status can be thought of as a loss of indigenesness imposed on a species by non-apt human behaviour. Through the compassion that comes from the dismantling of the dualism we may be spontaneously moved to act to preserve threatened species and to redress the wrongs committed against the environment by non-indigenous or unsustainable actions (*cf* Norton, 1987). The practice of conservation and ecological restoration now becomes an expression of compassion for the landscape. The goal may be to restore aptness or indigenesness to threatened species by manipulating the post-colonial environment.

In many cases it may be necessary to extirpate certain species in order to restore a habitat.

Through this line of reasoning we arrive at a paradox. How can the destruction of a population of, say the rabbits on Quail Island, be an expression of compassion for the other, as rabbits are clearly also the other? It is at this point the ethical approach described by Scott (1986) and the post modern approaches meet. For example, rabbits are the principal stressors that inhibit the natural recovery of forest on Quail Island (Chapter 7.3.2). In other words the ecosystem may be regarded as "sick" and "in need of a cure" (The use of the analogy of ecosystem health in restoration and monitoring is controversial and is discussed further in Chapter 9.1). By not removing this stressor we deprive numerous threatened populations of potential habitat and this would be a display of indifference to a greater suffering. Taking this sort of action could be thought of as analogous to a surgeon severing a limb to save a life. By not going

through with the operation because of the pain it might cause the patient and the surgeon, there would be a worsening of the patient's condition. This can be regarded as an expression of squeamishness and it is ethically reprehensible (Davies, 1986).

Clearly in order to make a decision that will lead to a reduction of the most suffering, a value judgement is required. Such a judgement cannot be made without assigning moral worth and value to species and populations, even though we know they are linguistic inventions. I believe that this is unavoidable.

In summary, in comparing the two approaches we find that both require values judgements of species, which are based on their perceived functional worth to the overall "health" of the biosphere. As we all value differently, relativism is the result. Relativism requires negotiation in order to arrive at some collective decision on what we value (Weaver, 1994) and in what way we manage restoration projects. The advantage of the post modern approach is that it permits relief from the blanket disdain for all post colonial species. Here everything, regardless of whether it has moral value or not, regardless of whether it is indigenous or exotic, good or bad, deserves to be treated with compassion. This gives conservation a break from the constraining mind-set that alienates people from the landscape. I would like to suggest that the postmodern approach is a more practical means to address the problem of the loss of biodiversity than through the ethical approach provided by Scott (1986), or the naturalness paradigm advocated by O'Connor *et al.* (1990).

2.4 The Contemporary Ecosystem (CE).

In terms of the postmodern approach all species can be viewed as "indigenous to the earth." (Heidegger cited in Weaver, 1994) and thus natural. The terms "indigenous", "exotic", "natural" and "unnatural" in regard to species and ecosystems can therefore be dispensed with. Naturalised exotic species could now be referred to as post-colonial species and those species present before the 1840 datum could be thought of as pre-colonial species. Where together these species can be shown to be in a state of

equilibrium, one could call this a Contemporary Ecosystem (CE).

Because of the pervasiveness of post-colonial species all restorations will result in a mix of these two elements. It was previously thought that owing to the apparent ecological superiority of European introduced species over species indigenous to New Zealand, British species would eventually supplant the New Zealand biota (Darwin, 1859 p.272). This notion remains unsubstantiated. This is not to underestimate the potential damage that some weedy species (e.g. *Clematis vitalba*) can do, it is to emphasise that such malicious species are in the minority and the majority of naturalised introduced species have a minimal impact on conservation values. Those environments most at risk of invasion and take over are forest fragments close to human habitation and sites of disturbance. In contrast intact native forest remains largely impermeable to invasion by weeds (Timmins and Williams, 1987,1991). This is largely true for post-colonial avifauna which are excluded from intact pre-colonial forest (McClay, 1974; Diamond and Vietch, 1981), although this is clearly not the case for the recently introduced mammalian species. Nevertheless ability of a predominantly pre-colonial forest to exclude weeds and some European birds highlights the importance of restoring forest to disturbance sites.

The central aim of ecological restoration should be to maximise the proportion of pre-colonial elements without upsetting the contemporary natural balance. One of the challenges is to demonstrate which post colonial species are, and which are not in a state of balance with pre-colonial species. Through the impracticalities of extirpating all exotic species from restorations they have been inadvertently identified as those species that facilitate predominantly pre-colonial forest recovery. That is, they are the "benign" exotic and self introduced species found around the middle of the species preference continuum. Those species considered not to facilitate a predominantly pre-colonial contemporary forest are usually found at the far right hand side of the continuum (Figure 2.1).

2.5 Conclusion

Conservation and restoration projects in New Zealand operate under the overarching tenet of what is "old" (pre-colonial) is "natural", what is "natural" is "indigenous" and what is "indigenous" is "good". In this chapter I have argued that this system of valuing ecosystems and species not only represents a static view of nature it is technically unsustainable. Furthermore it perpetuates the human/nature dualism which is one of the principal causes of the environmental crisis.

Once the duality is dismantled all species can be better understood in terms of their functional role in the ecosystem; that is all species can be treated as "indigenous to the earth". "Native", "exotic" and "self-introduced" taxa have been re-grouped into two broad categories. Species present before the 1840 datum are classed as "pre-colonial species" while species that arrived after this datum are referred to as "post-colonial" species. When there is an equilibrium formed between the two groups I have termed the resulting ecosystem a "Contemporary Ecosystem."

This does not mean that the preservation of pre-colonial biodiversity is not a priority. It is argued that through compassion, which results from the dissolution of the human/nature duality, we have a duty to mitigate the wrongs committed through unsustainable activities. In regard to the ecological restoration of Quail Island we have a duty to maximise the proportion of pre-colonial species to post-colonial species where appropriate. Through these arguments we are better equipped to accept the inevitable semi-natural outcome.

Chapter 3:

Assessment of the Natural Environment of Quail Island (*Otamahua*)

3.0 Introduction

This chapter gives an overview of the abiotic and biotic environment of Quail Island. In section 3.1 the island is posited in a bioclimatic zone, which permits an initial estimation of the character of the antecedent vegetation. In section 3.2 brief descriptions of the island's geology, soils, climate and hydrology are provided. In section 3.3 the island's vegetation and landform-vegetation relationships are examined using literature reviews and personal observations. In order to find meaning in the vegetation change sequences occurring on Quail Island and to build up a practical and ecologically appropriate restoration pathway, a study of the more advanced vegetation change sequences occurring on Mansons Peninsula was carried out. In section 3.4 a qualitative review of the extant faunal communities of Quail Island is given; emphasis has been on terrestrial vertebrate communities. In the conclusion of this chapter the distribution patterns are explained and summarised in terms of a prioritised list of natural and cultural environmental filters.

3.1 Banks Ecological Districts and Bioclimatic Zones

New Zealand has been divided into a series of "biogeographical provinces" known as Ecological Regions which have been subdivided into smaller Ecological Districts (Park *et al*, 1983; Park and Kelly, 1986). Banks Peninsula is a volcanic massif jutting eastward into the South Pacific from the margin of the Canterbury Plains (Burrows, 1994) and constitutes a single Ecological Region. The region is characterised by a climate that is warmer than the rest of Canterbury. For this reason it is the southern limit for many cold intolerant pre-colonial plant species not found south of Gore Bay,

such as, kawakawa (*Macropiper excelsum*), titoki (*Alectryon excelsus*), poroporo (*Solanum laciniatum*), akeake (*Dodonea viscosa*) and native passion vine (*Passiflora tetrandra*) (Wilson,1992a).

The region has been divided into three Ecological Districts: Port Hills, Mt. Herbert and Akaroa. Quail Island lies on the boundary of the Port Hills and Mt. Herbert Ecological Districts (Figure 3.1). The definition of these Ecological Districts was based on vegetation patterns, invertebrate distribution, rainfall and geology¹ (Wilson,1992). Conditions become cooler and more humid eastward across Banks Peninsula which is reflected in changes in floristic composition (Laing,1919; Johns,1986; Lilley,1990; Wilson, 1992a). Most notable is the presence of red and black beech (*Nothofagus fusca* and *N.solandri*), nikau palm (*Rhopalostylis sapida*) and mamaku tree fern (*Cyathea medullaris*) in lowland and coastal areas of the eastern part of the peninsula (Laing,1918; Lilley,1990; Wilson,1992a).

There is also a strong altitude and rainfall relationship that has led to the recognition of a vertical bioclimatic zonation pattern within each district (Wilson, 1993). Wilson (1993) has stratified the Peninsula into four bioclimatic zones (Figure 3.1) which are indicated by the altitudinal ranges of a number of species. Firstly the "subalpine zone"(approximately 750-900m asl) and three tentative lower zones: the "upper cool temperate zone"(500-750m asl), the "lower cool temperate zone" (sea level-500m asl) and finally the "maritime-cool temperate zone" found only in the warmest coastal microclimates of the Akaroa Ecological District lying between sea level and 100m. This zone is characterised by warm temperate forest elements of nikau palm, mamaku tree fern and shining broadleaf (*Griselinia lucida*).

Subhumid and humid components to the "maritime-cool temperate zone"

¹ Wilson(1992a) cautions that the boundaries are somewhat arbitrary and they should be used only as a general guide.

Quail Island rises from sea level to a maximum elevation of 86 m. It is warmer and less humid than the Akaroa District. It probably supported a more subhumid maritime forest vegetation characterised by drought tolerant species such as ahiraho (*Olearia paniculata*), akeake (*Dodonaea viscosa*), titoki (*Alectryon excelsus*), kaikomako (*Pennantia corymbosa*) and ngaio (*Myoporum laetum*).

Based on evidence from the literature it is my opinion that the "maritime-cool temperate zone" could be subdivided into humid and a subhumid components. For example the humid component is probably confined to the eastern tip of the Akaroa Ecological District as described by Wilson (1993), while the sub-humid segment follows the 700mm-800mm rainfall isoyhet (Fig.3.2 after Jayet,1986). This extends around the north and south coast of the peninsula and around the foot of the Port Hills where the vegetation loses its maritime character and becomes increasingly continental.

The upper limit of the maritime-cool temperate zone set by Wilson (1992) is controversial. Evidence from the literature suggests that it is possible that the zone probably extends inland from sea level to about 270m. For example the zone is delineated by the distribution of Birdlings Flat loess deposited between sea level and approximately 270m (Griffiths,1973; Figure 3.3). This material forms the parent material for the zonal yellow grey earth series that are characteristic of these subhumid conditions (Griffiths,1974; McClaren and Cameron,1990). Furthermore as one descends from 500 m to sea level through the "lower cool temperate zone" conditions become relatively drier and warmer and there is a noticeable change in vegetation from below 270m (Johns,1986). There is a steady increase in the diversity and abundance of cold-intolerant (Wilson,1993) species. Johns (1986) also notes a significant change in the invertebrate fauna below this level. Additionally the distribution of *Convolvulus verecundus* (waitaha) appears to closely follow the sub-humid rainfall band (Figure 3.1 after Wilson,1992 cf Figure 3.2 after Jayet,1986). Its northeastern limit occurs at the southern side of LeBons Bay and its southeastern limit at southern headland at the mouth of Akaroa Harbour.

Unfortunately, because the coastal zones of Banks Peninsula were favoured for Polynesian and European settlement, navigation and agriculture, by the turn of the nineteenth century virtually all of the forest vegetation in both the sub-humid and humid maritime zones had been destroyed (Petrie,1963; Thomas,1987; Figures 4.2 & 4.3). The vegetation that now occurs in this zone is mainly coastal scrub and tussock grassland. Only one tiny old growth remnant of this forest remains, at Ngaio Point in Akaroa Harbour which falls into the humid component of the maritime lowland zone. However in this zone and the sub-humid zone there remains a small but significant amount of second growth forest such as North West Bay in Okains Bay (see Chapter 4 for full list of relevant forest fragments or restoration reference states). These provide powerful clues as to the composition of this maritime forest. The only remaining comparable and extensive coastal forests of this type are probably the second growth coastal broadleaf forests along the Kaikoura coast and at Gore Bay.

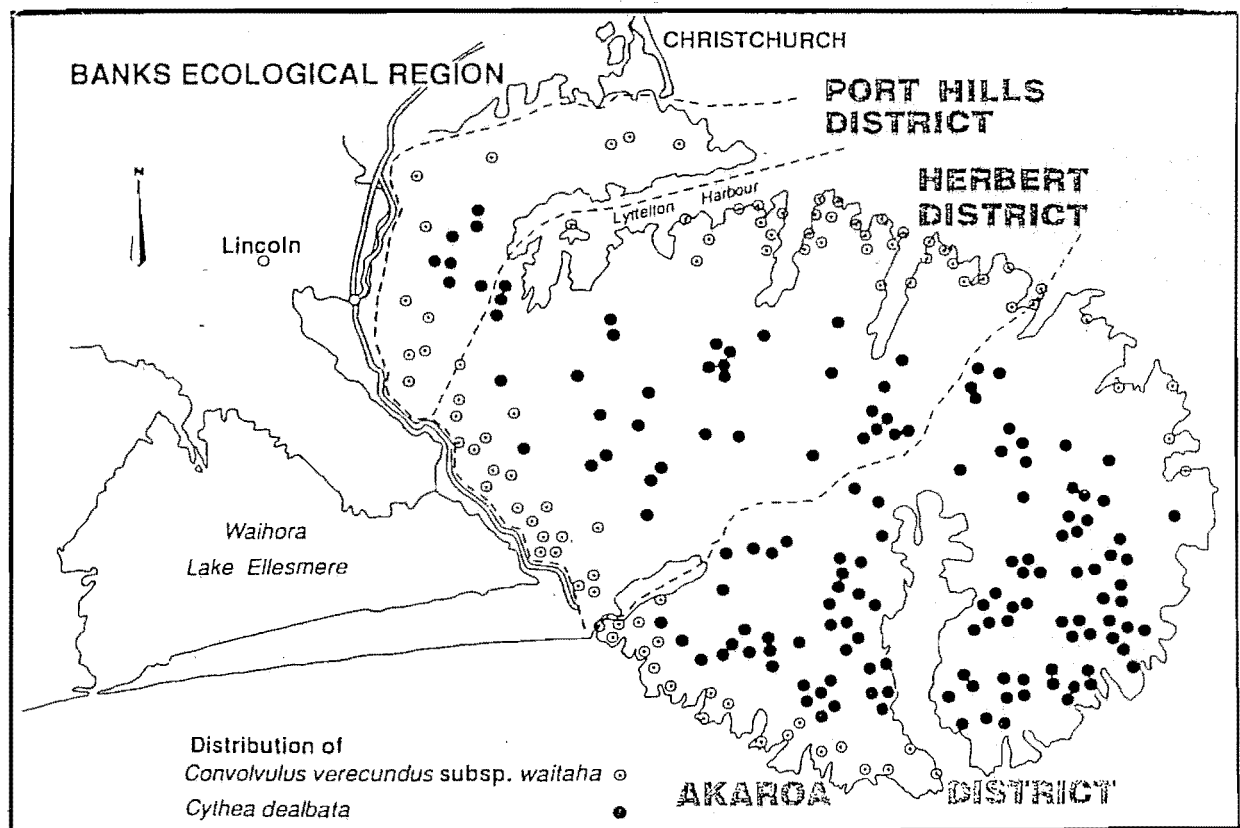


Figure 3.1 Banks Peninsula Ecological Region and Ecological Districts. Map shows the distribution of *Convolvulus verecundus* waitaha and the silver tree fern *Cyathea dealbata* (After Wilson,1992a p.50).

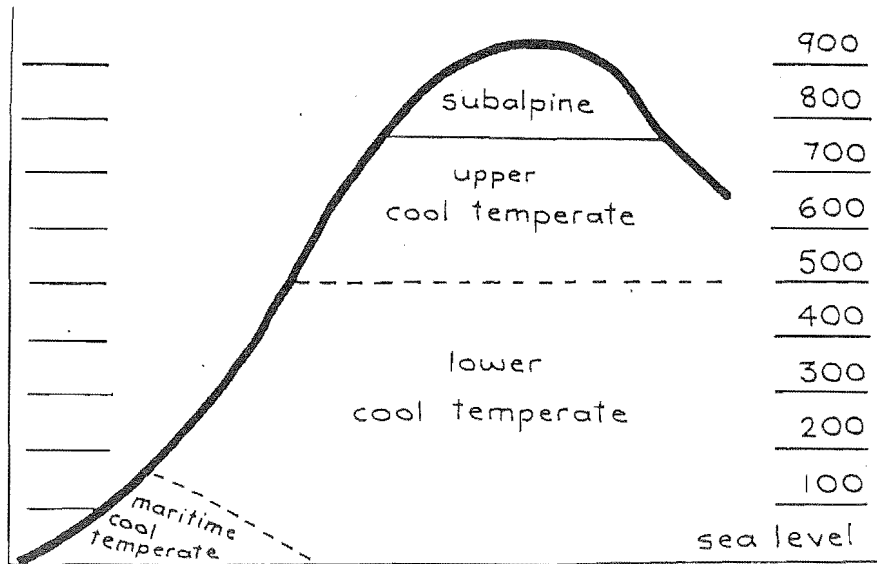


Figure 3.2 Banks Ecological Region bioclimatic zones (after Wilson, 1993)

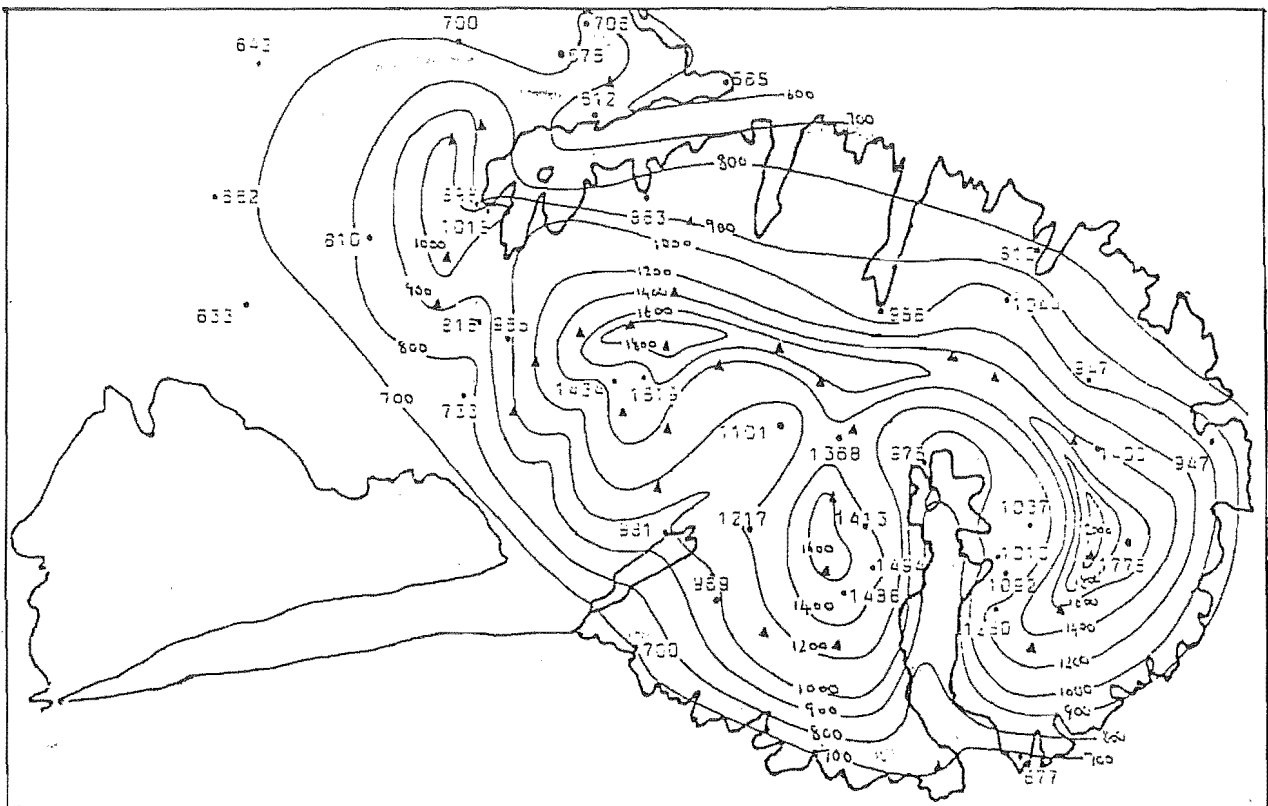


Figure 3.3 Banks Peninsula mean annual rainfall (after Jayet, 1986)

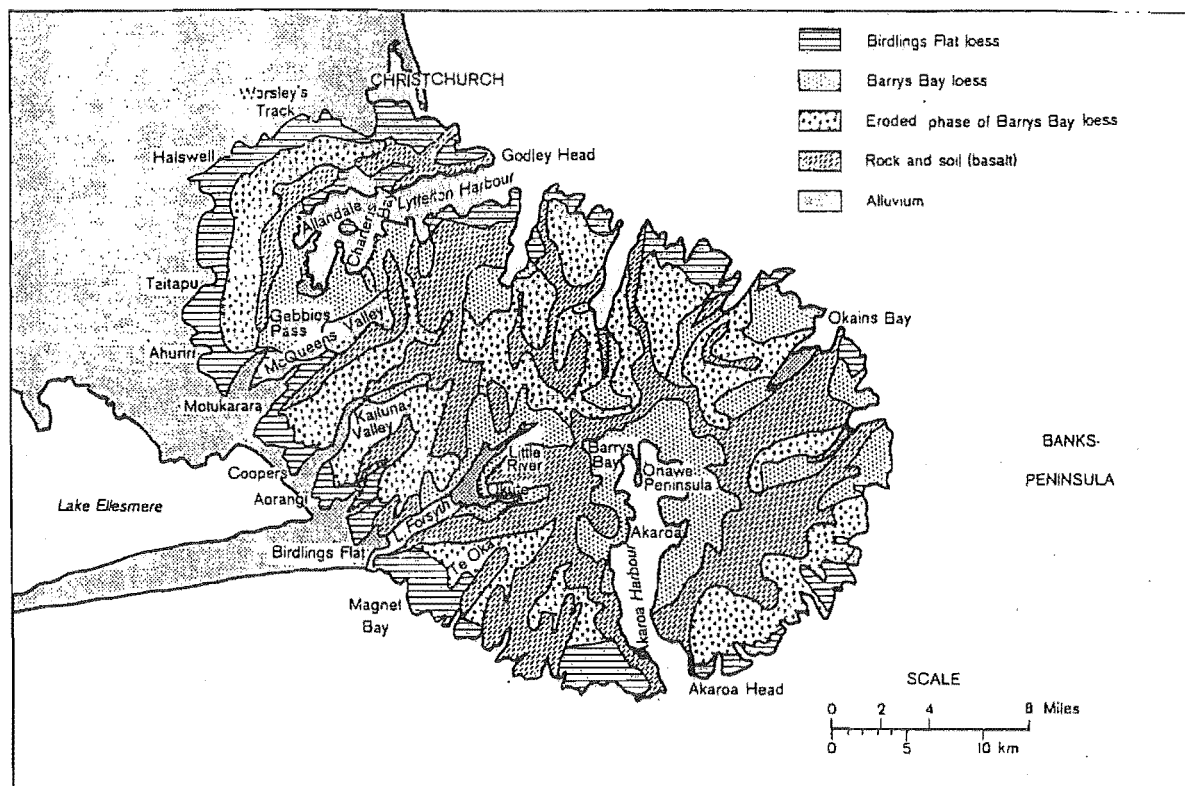


Figure 3.4 The distribution of loess on Banks Peninsula (Griffiths, 1973)

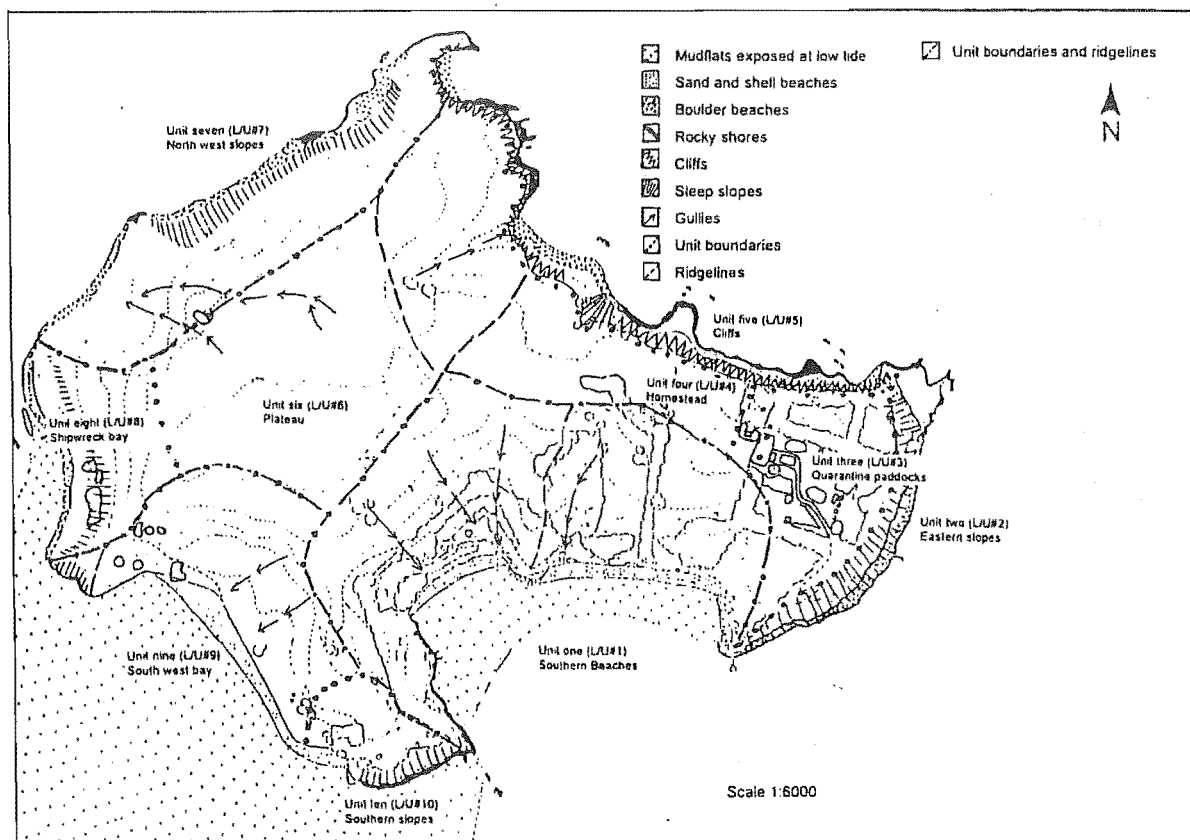


Figure 3.5 Quail Island landscape assessment (map adapted from Butcher *et al*, 1979 cited in Ford, 1980).

3.2 Topography, geology, soils, climate and hydrology of Quail Island

Sisson (1976) recognised five topographical units: i) Flat to gently sloping beach and seashore area, ii) Flat to rolling summit areas, iii) Moderately steep to steep slopes, iv) Steep to severe slopes and v) Sea cliffs. These zones were then subdivided into ten landscape units based on aspect and land use history (Department of Lands & Survey, 1983) (Figure 3.5).

Geology

Banks Peninsula formed during six volcanic episodes occurring over a period from 15 mya to approximately 7.3mya. The geological formation of Quail Island is complex involving all but the Akaroa volcanic period. The island is comprised of approximately one third allandale rhyolite, two thirds basalt on an ancient sand stone base (Weaver *et al*, 1985).

During the Quaternary glacial period Quail Island and the rest of Banks Peninsula was completely covered by thick layers of loess. Most of this material was subsequently eroded from the upper slopes and deposited lower down as loess and loess colluvium so that loess is thickest on hill summits and on hill toeslopes. Due to the greater thickness of loess on the lower slopes the influence of the bedrock on soil formation is usually negligible.

Soils of Quail Island

No detailed soil survey of the island has been conducted. Quail Island soils and those of the surrounding harbour are naturally "semi-fertile" (Sisson, 1976). The island's soil pattern is determined chiefly by topography. There are two soil units mapped on Quail Island: Takahe soils and the Takahe-Kiwi soil association. Takahe soils are located in the centre of the island and are formed on greywacke loess of varying thicknesses overlying basalt. Takahe-Kiwi soil association is found on the margins of the island where the loess parent material is relatively thin. It is comprised of two soil types: The

Kiwi Hill soils are formed on loess colluvium <1m thick and in places containing basalt fragments. The Takahe Hill soils have developed in the same parent material except it is >1m thick. In the north western and south western slopes (L/U# 7,8 & 9; Figure, 3.5) the soils are largely undisturbed and have considerable heuristic value (Molloy,1978).

Climate and Hydrology.

Temperature

There is insufficient meteorological data for Quail Island to yield any reliable trends. Nevertheless there are climatic models available so that predictions can be made at a local level with varying degrees of sensitivity. Temperatures on Banks Peninsula are strongly influenced by proximity to the sea, aspect and altitude. Southern aspects are cooler and more humid than the northern sites. This is because they face the rain bearing southwest winds, receive less direct sunlight and because they are largely protected from the desiccating effects of the northwest föhn wind. Temperature increases with a more northerly aspect, increasing with declining altitude and distance from the sea (Cherry,1987; Wilson, 1992a; Wilson and Wright, 1995). To this effect the southern aspects of Quail Island would be cooler and warmer than the northern aspects and less prone to drought.

Quail Island has a comparatively mild and frost free climate, giving it a relatively long growing season (Sisson, 1976; Jackson, 1990). Frost free sites are likely to be seaward slopes that face the prevailing easterly wind, such as Landscape Units 3, 4 and 6 (Figure, 3.5).

Temperature extremes have a great influence over plant growth, survival and distribution (Trewartha,1943; Innes and Kelly,1992; Maueth,1991). Compared to upland regions such as Mt Herbert, Quail Island has a mild climate. Mean annual temperature, the summer maximum and winter minimum were calculated for the summits of Quail Island and Mt.Herbert using Norton's (1985) model. It predicts a mean annual temperature normal at the summit of Quail Island to be 14.07 +/- 0.5°C

(Table 3.1).

	Quail Island	Mt Herbert
Summer maximum:	22.7 +/- 1.1 °C	14.95 +/- 0.9 °C
Winter minimum:	6.2 +/- 1.4 °C	-5.0 +/- 1.4 °C
Mean annual temperature:	14.07 +/- 0.5 °C	11.73 +/- 0.5 °C

Table 3.1 Temperature normal predictions for Quail Island and Mt. Herbert using formulae developed by Norton (1985) (see Appendix 1 for calculations).

Wind and Rain

The prevailing wind blows from the northeast (60°). It is strong and brings extended periods of fine rain in the autumn and winter (Sisson, 1976). The northwest (330°) föhn wind occurs mainly in the summer and has a dramatic desiccating effect over the entire island. Most of the rain arrives with the south-west frontal system. The southern aspects receive the least direct sunlight and being sheltered from the northwest wind, retain more moisture necessary for successful forest seed germination. During the summer the northwest föhn wind is more frequent, but by this time, it is likely that both the northern and southern aspects of Quail Island suffer from drought.

Hydrology

On Quail Island and around the harbour basin reliable water sources are rare. This is likely to be due to two or three factors in combination. Firstly lowlying landforms, (<270m asl) without upland components, cannot benefit from runoff and seepage that originate from higher altitude precipitation and orographic cloud. Secondly owing to the island's volcanic character, what water that is able to seep through the waterlogged winter soils and loess mantle probably escapes through fissure in the rock and is lost from the island system (Weaver, pers com).

The island is dissected by a system of drainage channels that run from the plateau over

the coastal slopes to the sea's edge (Figure 3.5). The only reliable source of natural fresh water on the island is a seepage below the original house site (Figure 1.4) (Sisson,1976; Department of Lands and Survey,1983; Jackson,1990). The water shortage frustrated the island's farming ventures and saw the construction of a stock water dam on the northwest coast at the turn of the century and later a rainwater collection system on the northeast coast. Water is now pumped at "great expense" from Lyttelton and serves an amenities block and workers accommodation (Jackson,1990).

Erosion

All the major forms of loessial erosion such as gully, tunnel and mass movement occur on the island. The occurrence of erosion on the island is the result of the current and historical landuse management in concert with topography and geology. Areas most prone to erosion are those over 12° and subject to the greatest moisture fluctuations. Erosion sites represent ruptures in the grassland matrix and constitute important sites of invasion by woody forest precursors such as manuka (*Leptospermum scoparium*) and kanuka (section 3.3.5). Erosion potential on the island is exacerbated by very high rabbit numbers and lack of woody vegetation.

3.3 Vegetation

The southern half of the island is visually dominated by exotic shelter belts and deciduous plantations. From Charteris Bay, the island appears wooded with a mixed conifer and deciduous forest. This is in sharp contrast to the view afforded from Rapaki of the dry grasslands of the northern slopes (Sisson,1976). From both points of view the island may appear to some to be inhospitable to pre-colonial indigenous forest. A closer look reveals the island is conducive to this vegetation and the processes of contemporary forest recovery are active.

The aims of this section are the following: i) To describe the island's plant communities, ii) to interpret the broad vegetation patterns in terms of landform-vegetation

relationships, iii) to describe the usual sequences of vegetation change leading to forest on Quail Island and in the island's vicinity.

The vegetation of Quail Island was reviewed in a qualitative manner using aerial photographs, previous vegetation studies and field reconnaissance.

3.3.1 Plant communities

The island was surveyed briefly by Sisson (1976) and Chapman (1978). A comprehensive vascular plant checklist was developed by Molloy (1978) before the island was gazetted a Recreation Reserve in 1982. The island was surveyed again in the late 1980s as part of the Protected Natural Areas Programme (Wilson, 1992a). In all instances only the undisturbed northwest, west and southwest coasts of the island were found to have significant botanical values. Based chiefly on Molloy (1978), there are nine plant communities on the island of significance to the restoration concept, they are as follows: 1) "native forest" restoration plantings, 2) post-colonial trees (mixed conifer/hardwoods), 3) mixed pre- and post colonial grassland, 4) shrub and scrubland, 5) contemporary forest fragment, 6) beach, 7) cliff, 8) rocky outcrops, 9) wet depressions (Figure 3.6). A checklist of plants on Quail Island is provided in Appendix 2.

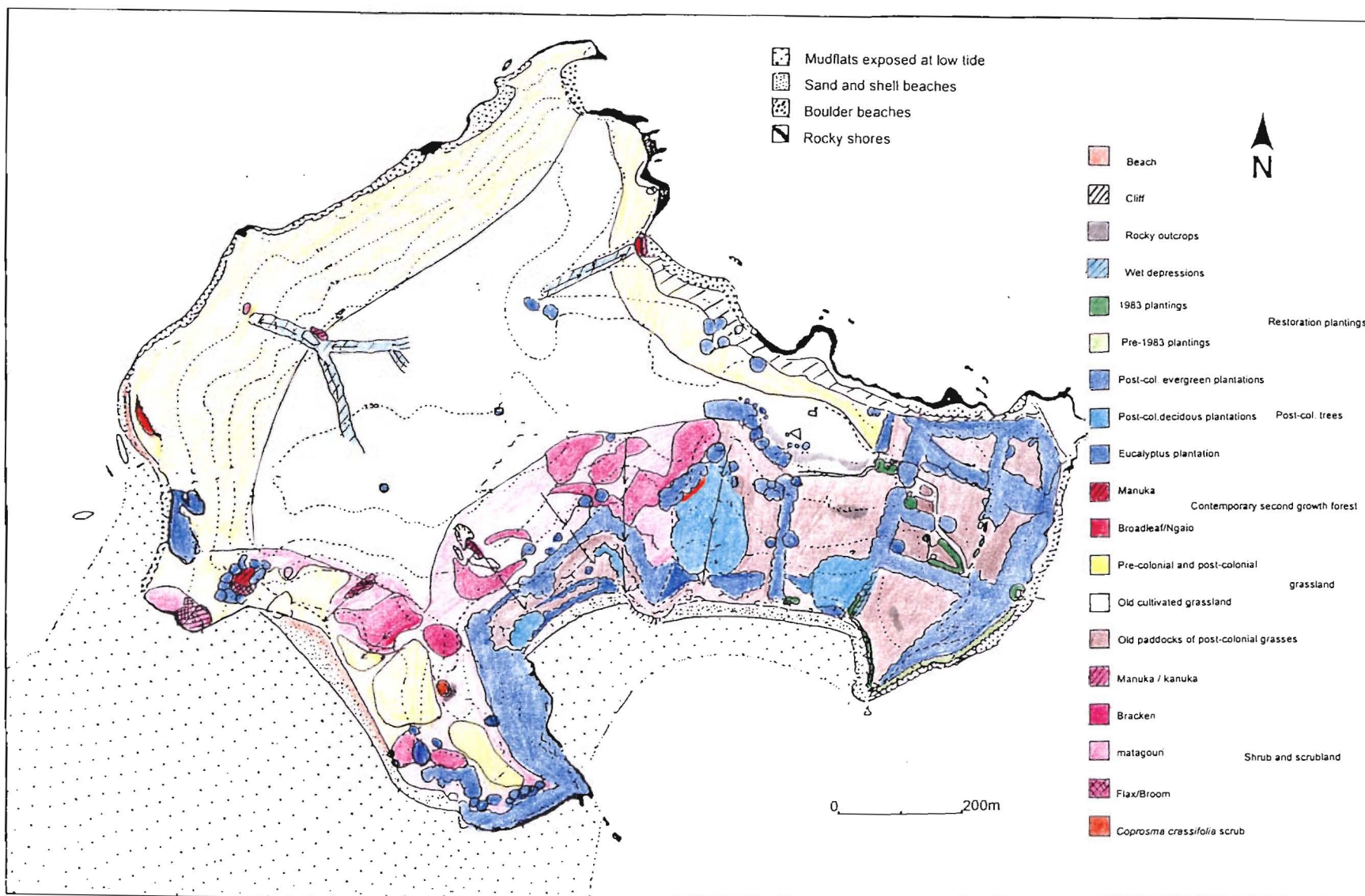


Figure 3.6 Vegetation map of Quail Island

3.3.1.1 Native Restoration plantings

The lists of originally occurring forest species are confused by occasional natives planted on the island as amenity trees before 1976. For example *Olearia traversii*, *Pittosporum raphii* and *P. crassifolium* were planted along the east coast (L/U #2). The specimens of *P. crassifolium*, *Olearia paniculata* and *Podocarpus totara* found around the homestead (L/U #4) were also planted at this time (Sisson, 1976). *P. crassifolium* did not survive at this site. Chapman (1978) records two small karaka trees (*Corynocarpus laevigatus*) at the reservoir and presumes they were planted by the Maori before 1850. However Molloy (1978) and Burrows (pers com) believe that they post-date the Maori occupation. At present only the one beside the reservoir remains.

In 1982 an attempt to revegetate the island was started by the Department of Lands and Survey (Jackson, 1990). Species combinations were based on lists of suitable plants for revegetation of Lyttelton Harbour devised after consultation with Brian Molloy (Claire Findlay, pers com). No records of the operation were kept but it was abandoned not long after commencement. Anecdotal reports claim that the majority of the seedlings perished through a combination of drought, salt damage from salt spray during southerly storms and notably through rabbit browse. However a small but healthy nucleus of native trees and shrubs survives in patches on the eastern (Figure 3.7), northeastern (Figure 3.8) and southern parts of the island (Figure 3.9). There is some regeneration beneath the stand surrounding the DoC shelter on the east coast (Frontispiece). Due mainly to the management of the area around the visitors centre (which may involve occasional mowing), there is no regeneration beneath this planted grove.

Those species planted but did not survive were likely to have been the following: shining broadleaf (*Griselinia lucida*), broadleaf (*Griselinia littoralis*), tree fuchsia (*Fuchsia excorticata*), *Hebe speciosa*, mahoe (*Melicactus ramiflorus*), mountain totara (*Podocarpus hallii*) and manuka (*Leptospermum scoparium*). Those species that survived and remain are displayed in the table below (Table 3.2). The most conspicuous successfully established trees are the coastal specialists, ngaio (*Myoporum laetum*) and

golden akeake (*Olearia paniculata*).

Table 3.2 Surviving planted native trees from revegetation attempt c.1982.

Species	Location
<i>Aristololia serrata</i>	L/U#3
<i>Coprosma propinqua</i>	not found
<i>Coprosma robusta</i>	2 plants ,L/U#3
<i>Cordyline australis</i>	occasional L/U#1,2, 3 & 4
<i>Hebe salicifolia</i>	occasional L/U#1,2, 3 & 4
<i>Hebe strictissima</i>	occasional L/U#1,2, 3 & 4
<i>Hoheria augustifolia</i>	L/U# 2, 3 & 4
<i>Kunzea ericoides</i>	L/U#1,2, 3 & 4
<i>Myoporum laetum</i>	L/U#1,2, 3 & 4
<i>Myrsine australis</i>	L/U# 1,2, 3 & 4
<i>Olearia avicenniaefolia</i>	L/U# 1, 3 & 4
<i>O. paniculata</i>	L/U# 1,2, 3 & 4
<i>Pennantia corymbosa</i>	L/U# 2, 3 & 4
<i>Phormium tenax</i>	L/U#1,2, 3 & 4
<i>Pittosporum eugenioides</i>	L/U#1,2, 3 & 4
<i>P. tenuifolium</i>	L/U#1,2, 3 & 4
<i>Plagianthus regius</i>	L/U# 2, 3 & 4
<i>Podocarpus totara</i>	L/U#1, 3 & 4
<i>Pseudopanax arboreus</i>	L/U#1,2, 3 & 4
<i>Sophora microphylla</i>	L/U#1,2, 3 & 4



Figure 3.7 1983 native forest restoration plantings at Visitors Centre L/U#4



Figure 3.8 1983 native forest restoration plantings at DoC shelter L/U#2

3.3.1.2 Post-colonial tree plantings

Between 1874 and 1900 the island was planted with exotic trees for both shelter and amenity. The shelter belts are 50% macrocarpra (*Cupressus macrocarpra*), 45% *Pinus radiata* and 5% *P.nigra* (Sisson,1976). *Pinus radiata* and *P.nigra* were planted in four localities to control erosion (Figure 3.6). In 1976 all exotic shelter trees were considered over mature and many were felled. The debris provided refuges for rabbits and for seedling regeneration. In the early 1980s the majority of the shelter trees that criss crossed the plateau were felled and most of the debris removed. The loss of debris probably led to a reduction in potential refuges for rabbits as well as seedling safe sites. Regeneration of macrocarpra and pine seedlings occurs on the edge of plantings and occasionally in open fields. Regeneration may occur elsewhere but the real patterns of regeneration are difficult to discern due to weed control by the Department of Conservation staff. The holm oak (*Quercus ilex*) planted on the east coast and along the beginning of central ridge line shelter belt is regenerating well (Figure 3.6).

There is a significant plantation of sycamore (*Acer pseudoplatanus*) and *Quercus sp.* at the old hospital site (Figures 1.2 & 3.6). Sycamore is usually considered an aggressive weed (Wardle,1983; Porteus,1993) but it is regenerating in only two sites above the southern beaches region. Beneath the canopy of *Quercus sp* there is very little regeneration.



Figure 3.10 Exotic amenity plantation; sycamore, macrocarpa, *Quercus sp* and *Pinus spp.*, photograph taken from Waterski Beach beside Swimmers Beach (L/U#1).

3.3.1.3 Mixed pre- and post colonial grassland

The ubiquitous exotic grasses of cocksfoot (*Dactylis glomerata*) sweet vernal (*Anthoxanthum odoratum*) and brown top (*Agrostis tenuis*) continue to dominate most sites. This is especially noticeable in the old fields of the plateau (L/U#6; Figures 3.5, 3.6 & 3.11). The early surveys of Sisson (1976) and Molloy (1978) show that there has been comparatively little change in this area. The silver tussockland (*Poa cita*) above South-West Bay (Walkers Beach L/U#9) is being out competed by cocksfoot, although bracken and other transitional forest species are making considerable ground into grassland. However the native grasses such as wheat grass (*Elymus recticetus*) predominate in areas that were probably never oversown with exotics and in areas of

past disturbance. On the steep northern slopes wheat grass (*Rytidosperma clavatum*) and occasional clumps of silver tussock are found.

3.3.1.4 Scrubland

Scrubland is defined here as complexes of bracken and small leaved shrubs forming stands scattered over a grassland matrix. Significant stands of scrub occur in the southern regions, where scrub appears to be overtaking grassland. On the opposite side of the island grassland is still dominant.

Scrubland on the northern half of the island

The northern half of the island is essentially mixed grassland with scattered patches of scrub and shrubland. This area can be divided into northwestern and north eastern sections. The northwestern area comprises Shipwreck Bay (L/U#8) and North West Slopes (L/U#7). Although neither landscape units were oversown or cultivated in European times, post-colonial grasses have made advances into the pre-colonial grassland matrix. Within these two units there are relatively small patches of scrub located only on the southern facing safe sites, usually where there has been a history of erosion.

Scrub may be comprised of scatterings of woody species such as, scrub pohuehue (*Muehlenbeckia complexa*), flax (*Phormium tenax*), *Coprosma crassifolia* or native broom (*Carmichaelia robusta*). These species may combine under the domination of *Coprosma crassifolia* to form small dense stands often bound together with a smothering of climbers such as bush lawyer (*Rubus squarrosa*) and pohuehue (*M. australis*). This forms a canopy that provide microsites for shade-tolerant woody species which may form a scattered understorey. This understorey is usually small and made up of rabbit resistant species such as poroporo, *Urtica ferox*, *elder, *flowering currant and ferns, such as Richards shield fern (*Polystrichum richardii*). Against the

escarpment one finds Valerian (*Centrathus ruber*) and the leather leaf fern (*Pyrossia serpens*). It is likely that in the absence of rabbits, this vegetation would be transitional to forest. Two significant pockets of this type of vegetation are found against the south west faces at the foot of the coastal escarpment at shipwreck Bay (L/U#8), the largest is depicted in Figure 3.12 (see also Figures 3.5 & 3.6). Large akeakes (either *Dodonaea viscosa* or *Olearia paniculata*) once stood at this site and were felled for firewood by the first European settlers (Ward, 1850).

In comparison to the southern side of the island manuka and kanuka are scarce in the northern regions. However at the stock water dam there is a thicket of manuka with considerable component of pohuehue (*M. australis*). There is no regeneration and the trees are over mature (Figure 3.13). This stand is depicted in the early plans for a proposed prison on Quail Island dated 1907 (Jackson, 1990 p.57) and it is possible that it pre-dates the European occupation of the island.

Scrubland on the southern half of the island

On the slopes in the southern regions mixed stands of scattered bracken and small leaved shrubs dominate. These are surrounded by scattered matagouri and cabbage trees in a complex of post-colonial and pre-colonial grasses. Occasionally one finds open stands of manuka, kanuka and *Coprosma crassifolia*. Thickets of *Coprosma crassifolia* can be found on sites with little soil such as rocky exposed ridges where there is little competition from grasses (Figures 3.5, 3.14a & 3.14b). The manuka and kanuka stands are both associated with erosion scars. Kanuka is able to establish itself on slips in the absence of a top soil giving them a competitive advantage over grasses (Wardle, 1991). The latter can be found above Swimmers Beach (L/U#1) while the former is located above South West Bay (L/U#9) (Figure 3.5, 3.14a & 3.14b). It is usual that manuka is found in moist conditions while kanuka in drier localities (Wardle, 1990). This does not appear to be the case on Quail Island, nor in the lowland maritime zone in the island's vicinity such as on Mansons Peninsula where kanuka and manuka

groves can be found adjacent one another.

The bracken stands are large and serve as a nurse crop for broadleaf forest colonisers such as mahoe, and poroporo (*Solanum laciniatum*) as well as **Pinus radiata*. Within this bracken matrix other species such as, flax, *flowering currant (*Ribes sanguineum*), *elder (*Sambucus nigra*), native nettle (*Urtica ferox*), native broom, *Meuhlenbeckia australis* and *M.complexa* are commonly found (Figures 3.15a & 3.15b). The presence of this vegetation is particularly significant for the restoration vision of Quail Island. Firstly bracken is indicative of forest climate and soils (Knowles,1970 cited in McGlone,1983) and its presence suggests that Quail Island is potentially a forest environment. Secondly this vegetation serves as a nurse canopy for pre-colonial forest species, marking the beginning of a sequence of vegetation change leading to a predominantly pre-colonial indigenous forest.

3.3.1.5 Self-introduced and remnant pre-colonial trees and shrubs

Most forest patches and scattered trees are located in the undisturbed northwest, west, southwest coasts and northeast cliffs region of the island. There has been little or no colonisation of the previously cultivated areas on the plateau (L/U#6) and in some cases there has been a loss of original species. For example kawakawa (*Macropiper excelsum*) is no longer found on the island. Table 3.3 lists those native woody species thought to be those originally present as well as those that have recently arrived unaided to the island (written in bold type).



Figure 3.11 Mixed pre-colonial and post-colonial grassland and scrubland on coastal slopes of South West Bay (L/U#9)



Figure 3.12 Pockets of mixed pre- and post-colonial shrubland in southern facing safe sites of northwest facing coastal slopes (Shipwreck Bay, L/U#8).



Figure 3.13 Manuka stand at the stock water dam, north west slopes (L/U#6)



Figure 3.14a Manuka, bracken, matagouri and cabbage tree in mixed grass matrix above Southern Beaches (L/U#1)



Figure 3.14b Manuka, bracken, matagouri and cabbage tree in mixed grass matrix above Southwest Bay (L/U#9)



Figure 3.15a An example of regeneration of mahoe, native broom, elder and *Pinus radiata* through bracken.



Figure 3.15b Scrub complex of bracken, flax, cabbage tree, broom and silver tussock near South West Bay.

Table 3.3 Self introduced and Remnant Pre-colonial Trees and Shrubs

1) North eastern sector of Quail Island.

<i>species</i>	<i>Molloy(1978)</i>	<i>Wilson(1992)</i>	<i>1995/96</i>
<i>Coprosma robusta</i>	<i>rare</i>	<i>not mentioned</i>	<i>rare, 2 planted in 1982, 1 plant occurs naturally in L/U #4. Fig 3.24</i>
<i>Melicytus ramiflorus</i>	<i>rare</i>	<i>present</i>	<i>rare, 1 occurs naturally L/U #10. Fig.3.22</i>
<i>Myoporum laetum</i>	<i>rare, 1 naturally occurring</i>	<i>present</i>	<i>Locally abundant. Most common planted tree.L/U#1,2,3 & 4</i>
<i>Griselinia littoralis</i>	<i>rare</i>	<i>not mentioned</i>	<i>rare, 1 old tree L/U#5</i>
<i>Myrsine australis</i>	<i>not mentioned</i>	<i>present</i>	<i>1 at L/U #5 & #2</i>
<i>Micropiper excelsum</i>	<i>1 specimen</i>	<i>1 specimen</i>	<i>Cannot locate.</i>

2) Southern half of Quail Island.

<i>Cordyline australis</i>	<i>occasional</i>	<i>not mentioned</i>	<i>present</i>
<i>Discaria toumatou</i>	<i>locally abundant</i>	<i>locally abundant</i>	<i>present</i>
<i>Leptospermum scoparium</i>	<i>locally abundant</i>	<i>present</i>	<i>present</i>
<i>Pittosporum tenuifolium</i>	<i>occasional</i>	<i>not mentioned</i>	<i>absent</i>
<i>Hebe salicifolia</i>	<i>not mentioned</i>	<i>not mentioned</i>	<i>1 specimen L/U #9</i>
<i>Kunzea ericoides</i>	<i>not mentioned</i>	<i>not mentioned</i>	<i>Several plants in slip areas L/U #9</i>
<i>Urtica ferox</i>	<i>rare</i>	<i>not mentioned</i>	<i>present beneath canopy</i>

3) West Coast of Quail Island.

<i>Hebe strictissima</i>	<i>rare</i>	<i>present Unit 9</i>	<i>absent but occasional in 1982 plantings</i>
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4) North West Slopes of Quail Island.

<i>Kunzea ericoides</i>	<i>rare, 3 plants</i>	<i>not mentioned</i>	<i>absent in this locality but occasional on L/U#9 and 1982 plantings L/U#1, 3 & 4</i>
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5) Found throughout Quail Island.

<i>Olearia paniculata</i>	<i>occasional throughout</i>	<i>present</i>	<i>present, naturally regenerating in L/U #2,5,9</i>
<i>Carmichaelia robusta</i>	<i>locally abundant</i>	<i>present</i>	<i>present</i>
<i>Solanum laciniatum</i>	<i>occasional throughout</i>	<i>present</i>	<i>present</i>

Since the island was declared a Recreation Reserve in 1982, *Hebe salicifolia*, kanuka and red matipo (*Myrsine australis*) are probably the only species that have arrived established unaided on the island. Kanuka has colonised the slip areas above South West Bay, L/U#9 (Figure 3.14b). *Hebe salicifolia* is rare and confined to the southern areas in sites out of reach of rabbits.

The species composition of the remnant tree list is very similar to the low canopy coastal broadleaf forests of Gore Bay in North Canterbury (Mason,1969) and the maritime lowland remnants at North West Bay in Okains Bay and Ngaio Point in Akaroa.

All the major components of the low canopy forest trees occur naturally on Quail Island with the exception of Putaputweta (*Carpodetus serratus*). Putaputaweta usually requires a moister environment than Quail Island can provide. Nevertheless the list of extant pre-colonial trees and shrubs indicates that island is probably hospitable to this forest type.

3.3.1.6 Contemporary second growth forest fragments

There are two small sites of contemporary second growth forest (Chapter 2.4) on Quail

Island. The first is the beginnings of a coastal broadleaf stand located below the freshwater seepage in L/U# 5 "Cliffs" (Figures 3.5, 3.6 & 3.16a). The other is a manuka dominated stand with considerable regeneration located in a major slip area at South West Bay/Walkers Beach L/U#9 (Figures 3.5, 3.6 & 3.16b). The two sites are described below.

Site 1: The seepage point is a very significant site for both plants and wildlife on the island. It is the only site of exposed fresh water on the island and it is a congregation point for many birds and mammals, furthermore it is a site of broadleaf forest regeneration. There are only two large trees in this stand; a large mature broadleaf (*Griselinia littoralis*) and a ngaio (*Myoporum laetum*) of similar size. The vegetation surrounding the broadleaf receives most of the water from the seepage and it is relatively lush. It is comprised of a complex of poroporo, flax, elder, flowering currant, *Muehlenbeckia complexa*, *M. australis* and *brier rose (*Rosa rubiginosa*), all of which are abundant and regenerating. The large ngaio has very little undergrowth, although red matipo (*Myrsine australis*), *Coprosma virescens* were present nearby. Large *elders have been felled as part of the DoC weed control policy. Other species present were: *Creeping mallow (*Modiola coroliniana*), *Cotula coronopifolia*, nettle leaved fathen (*Chenopodium murale*), Maori celery (*Apium prostratum*), *sow thistle/puha (*Sonchus oleraceus*) *watercress (*Nasturtium microphyllum*), *common vetch (*Vicia sativa*) and *foxglove (*Digitalis purpurea*).

Site 2: This site is surrounded by shelter pines planted to stabilise the slip area. Species present beneath the main canopy were, poroporo, flax, currant (*Ribes sp.*), cocksfoot, *Urtica ferox*, Richard's shield fern (*Polystichum richardii*), necklace fern (*Asplenium flabellifolium*). Associated with this grove were large stands of flax, bracken and elder. Bracken supports both *Muehlenbeckia australis* and *M. complexa*. Large elders have been felled as part of weed control. Manuka seedlings are very common in the grassland on the periphery of the forest stand. Invasion of the grassland is possible once the grass sward is thinned out by shading from the canopy.

3.3.1.7 Cliff Communities

The eastern cliffs (L/U#5, Figure 3.17) have a large array of plants not found elsewhere on the island. The majority of woody plants are wind dispersed, salt and drought tolerant post colonial species, such as *Boneseed (*Chrysanthemoides monilifera*), *Boxthorn (*Lycium ferocissium*) *Azolea sp, *Pinus radiat* and Holm oak (*Quercus ilex*). Also one finds the pre-colonial ahiraho (*Olearia paniculata*) and ngaio (*Myporum laetum*). The most obvious and ubiquitous species is the South African boneseed, which dominates the backshore of the gravel beach to the cliff face. Boneseed has made advances onto the periphery of the plateau. There is very little regeneration beneath this plant of itself or other species and it may have little use as a nurse species (see section 3.3 for further discussion).

3.3.1.8 Pond and wet depressions

Moisture loving plants accumulate along the natural drainage lines and around the stock water dam. Drainage lines that support this type of vegetation are indicated in Figure 3.10. The following species are found in these localities: watercress (*Nasturtium microphyllum*), *Juncus gregarflorus*, *Carex appressa*, *Scirpus nodocus*, pondweed (*Potamogeton sp*), callatriche (*Callatriche stagnalis*), creeping bent (*Agrostis stolonifera*), daisy (*Bellis perennis*), rush (*Juncus filicaulis*) and floating sweetgrass (*Glyceria fluitans*) (Figure 3.18).



Figure 3.16a An example of a fragment of contemporary second growth forest located below the seepage point L/U#5.



3.16b Contemporary second growth manuka forest fragment (L/U#9)



Figure 3.17 The north eastern cliffs (L/U#5) shows boneseed (*Chrysanthemoides moniliifera*) in flower which makes up the dominant canopy in this area. This plant is transitional to forest in its native South Africa .



Figure 3.18 Moisture loving vegetation develops in the wet depressions of the drainage line below the old Ward's house site (L/U#6).

3.3.1.9 Beach communities

Sarcocornia quinqueflora forms an extensive mat along South West Bay(L/U#9). Growing on the foreshore are *Puccinellia sp*, *Juncus maritimus*, cocksfoot (*Dactylis glomerata*), with Californian thistle (*Cirsium arvense*). *Festuca arundinacea* and Vulpia hair grass (*Vulpia bromoides*). On the rocky escarpments above the shore the leather leaf fern (*Pyrrosia serpens*) can be commonly found.

3.3.1.10 Rocky outcrops

Anise (*Gingidia montana*), stuartina (*Stuartina muelleri*), hard fern (*Blechnum penna-marina*) (Molloy,1979) are the common plants. Rocky outcrops and quarry rumble in the grassland matrix provide safe sites for pre-colonial species such as bracken, matagouri and *Coprosma crassifolia* (Figure 3.19).

3.3.2 Landform-vegetation relationships on Quail Island

The purpose of this section is to explain the natural vegetation patterns described above. Throughout lowland areas of Lyttelton Harbour, the landforms orientated towards the south are the first sites to be colonised by forest species. Despite the island's history of disturbance and its current management regime, this pattern is still discernable on Quail Island. The typical vegetation patterns in the Port Hills region are described by Griffiths (1974). For example manuka scrub develops on the sunny northern slopes while "bush"(broadleaf forest) appears on the southern slopes. Silver tussock is markedly denser on the moist southern sides compared to the northern sites. Rushes and sedges develop in the wet areas .

It appears that the dominant factor limiting the establishment of forest propagules in these areas is the availability and distribution of moisture during the period of summer

drought. There are three factors that enable moisture to accumulate and persist in the southern facing aspects of landforms. Firstly they are exposed to the moist southwesterly frontal system, secondly they are sheltered from the higher levels of direct sunlight that characterise the northern aspects and finally they are sheltered from the desiccating effects of the north west summer foehn wind.

On Quail Island the southern undisturbed soils support mixed matagouri, silver tussock, post-colonial grasses and bracken scrub. The bracken stands are important "safe sites"² for early broadleaf pre-colonial forest colonisers. In contrast the old fields of the northern side remain in exotic grasses with little or no colonisation by pre-colonial scrubland species. On the undisturbed north-western slopes native grasses dominate, but in these drier conditions silver tussock is found in comparatively lower densities. Woody vegetation is usually confined to southern facing sites.

The distribution of bracken and tussock on Quail Island can be explained through the probable distribution of effective rainfall and the island's fire history. Wardle (1991 p.264) explains that after forest fires in areas of moderate rainfall (>760mm p/a) bracken fern will colonise the site. After fire disturbance in low rainfall areas (<760mm) previously forested ground reverts to grassland. Although rainfall from one side of the island is unlikely to differ, the effective rainfall will differ in accordance with the influences of aspect. This may explain the concentration of scrub on the southern side of the island.

3.3.3.0 Old field vegetation change sequences in the vicinity of Quail Island

Since the decline in the farming sector much pastoral land has been taken out of production. In forest environments such as Banks Peninsula there is a steady return of bracken, scrub and second growth mixed broadleaf forest. The colonisation of

²"Safe sites" is a term coined by Luken (1990) to refer to places where forest seedlings can establish out of danger from browsers and harsh abiotic environmental conditions.

abandoned farmland (mainly cultivated fields) by woody species is termed Old Field Vegetation Change (Burrows, 1991 p.359). The process is particularly noticeable on the southern sides of the Lyttelton caldera, for example at the Crater Rim Walkway, Sugar Loaf Scenic Reserve and on the lowlying peninsulas neighbouring Quail Island of Moepuku Point and Mansons Peninsula (Figure 1.1).

The sequence of change is variable. The sequence for pasture is different to that of mainly cultivated fields, varying with environmental factors, the availability of propagules and seedling "safe sites". The following is a review of the observed vegetation change sequences in the vicinity of Quail Island, followed by a description of the sequences occurring on Quail Island itself. The former involves a description of Gorse-Broom -Elder-Mahoe Sequence occurring throughout the Lyttelton Harbour Basin and Port Hills. This is followed by a description of the role of flax as a nurse crop for broadleaf pre-colonial forest colonisers. In the next section the role of birds in forest recovery is briefly discussed. This material forms part of the theoretical basis for the development of a restoration strategy that aims to mimic and accelerate the natural forest recovery processes (Chapter 8).

3.3.3.1 Gorse-Broom -Elder-Mahoe Sequence

Gorse and broom are part of a vegetation change sequence that leads to mahoe dominated second growth native forest on the Port Hills (Williams, 1983; Lee *et al*, 1986; Partridge, 1992; Wilson, 1992a, 1993; McCracken, 1993; Meurk, 1994). On the northeast slopes of the Crater Rim Walkway reserve near the Sign of the Kiwi the usual successional pattern are variations on the Port Hills model described by Williams (1983). Often karamu (*Coprosma robusta*) is observed growing through the broom or bracken, also Fuchsia (*Fuchsia excorticata*) will colonise the grassy margins of the Ahuriri Bush forest reserve and serve as nurse crop for a variety of forest broadleaves.

3.3.3.2 Flax as (*Phormium tenax*) a nurse species

Flax (*Phormium tenax*) serves as a major nurse species for forest broadleaf species on the southern facing slopes of the Crater Rim Walkway. Common nectarivorous species such as silvereyes (*Zosterops lateralis*), bellbirds (*Anthornis melanura*) and European starling (*Sturnus vulgaris*) feed frequently on flax blossom, spreading forest broadleaf seed into flax clumps. With sufficient moisture and a deep enough layer of litter around the base of the clump or in the centre, seeds of forest broadleaf species will germinate, eventually overtopping the flax clump. Trees observed were Mahoe (*Melicytus ramiflorus*), red matipo (*Myrsine australis*), black mapou (*Pittosporum tenuifolium*), five finger (*Pseudopanax arboreus*), karamu (*Coprosma robusta*), shining karamu (*C. lucida*) and *Coprosma* sp. On the northern face of the adjacent valley only two flax clumps were observed and *Muehlenbeckia complexa* was the only woody species observed inside the clumps. It is possible that in order for flax to operate as a nurse crop there must be sufficient moisture, forest propagules and birds to act as mobile links.

3.3.3.3 Birds and Vegetation Change

Over three quarters of New Zealand's forest trees have fleshy fruit and the chief agents of dispersal are birds (Burrows, 1994). The most important seed dispersers in Banks Peninsula are blackbirds and silvereyes; without them native forest regeneration in the Port Hills would be minimal (Burrows, 1994). In open fields, birds are attracted to woody vegetation which provides shelter and perch sites (Reay, 1996; McDonald and Stiles, 1983; McClanahan and Wolfe, 1987; Robinson and Handel, 1993). This can result in an exponential increase in woody plant densities and a concomitant number of visits by birds (Robinson and Handel, 1993).

Quail Island is a significant distance from large sources of forest propagules³ and this may slow down forest recovery (*cf* McCracken, 1993). Although it is acknowledged that long distance seed dispersal plays a vital role in forest recovery, fruit eaten in the forest will be generally ejected in the forest. Usually it is rare to find forest seed further than 2 km from the propagule source (Burrows, 1994). It is likely that foraging silvereyes, blackbirds (*Turdus merula*) and starlings spread seed from fruit foraged on the island rather than importing it from other localities.

3.3.4 Vegetation Change Sequences on Quail Island

Apart from the strong evidence provided in the literature that suggests Quail Island has a forest environment and probably supported a forest in pre-settlement times, there are at least three main factors from the vegetation patterns on the island to support this. Firstly the principal woody species components of a maritime forest occur naturally on Quail Island. Secondly there is regeneration of these species and of planted pre-colonial species in some sites after rabbit control programmes. Thirdly the presence of percussorial forest vegetation such as large and spreading stands of silver tussock, bracken, matagouri, cabbage trees and other small leaved shrubs are indicative that the island may have supported an antecedent matai/broadleaf forest (*cf* Molloy, 1969; Brian Molloy, pers com). As bracken and tussock grassland is transitional to forest in this climate, the island would have had to be regularly burnt to maintain this vegetation.

The tussock, bracken, matagouri communities of the southern slopes were never cultivated and have not been grazed for over 17 years. From early aerial photographs there appears to be a spread within the southern landscape units of bracken, manuka, kanuka and flax, but a decline in *Poa cita* since grazing ceased (*cf* Lord, 1991). These

Quail Island is approximately 4.5 km from the nearest mature podocarp-broadleaf forest at Kennedys Bush. It is approximately 2.5 km from regenerating coastal broadleaf forest fragments at Governors and Sandy Bay and <2km from Rapaki (Figure 1.1). On the NW sides of the harbour the nearest forest reserves are at Orton Bradly some 5km from the island and the Hunter Native Reserve, <2km from the island.

changes are occurring in accordance with a discernable pattern described below.

It appears that on Quail Island post-colonial species tend to dominate the most fertile soils often leaving pre-colonial species to occupy the harshest and disturbed sites where they may have a competitive edge. Sites where woody vegetation can take hold marking the beginnings of forest recovery, have been termed "Contemporary Forest (CF) recovery sites". Eight such sites have been identified, they are as follows : i) inland rocky outcrops. These are often colonised by *Coprosma crassifolia* which form dense thickets providing a micro climate for other forest species. It produces fleshy fruit and its seed may be dispersed by geckos which are common on the island (Figure 3.32).

ii) Coastal rocky escarpments and other sites beyond the reach of rabbits. It is common to find the wind dispersed ahiraho, gorse, broom and boneseed in these sites as well. In shadey aspects Richards shield fern and the leatherleaf fern are common. iii) Tunnel erosion gullies, slips and small disturbances in grass swards. These sites are colonised by manuka, kanuka and occasional gorse and broom. Cabbage tree, flax and matagouri may colonise small disturbances and gaps in the grass sward. iv) The southern sides of spurs and escarpments on northern landforms. Frequently it is pohuhue (*Muehlenbeckia complexa*) that is the first to penetrate the grass swards. This creeper also behaves like a climber and is able to use other early colonisers such as bracken, elder and poroporo as support. v) Fallen trees and stumps where grasses are marginalised by shading. These sites are colonised readily by poroporo, elder and flowering currant (Figure 3.32). vi) Isolated shadey moist places. These sites may be colonised by any shade tolerant species. vii) Dead annual herb forbs and annual grass swards. viii) Beneath the canopy of nurse trees such as macrocarpa, *Pinus radiata* and manuka. On the east coast of the island numerous ahiraho seedlings can be found. *Hebe salicifolia* and niniao (*Helichrysum lanceolatum*) have also been noted. The seedlings of manuka, *Pinus radiata* and macrocarpa will invade grassland. This usually occurs from the periphery of the adult canopy. Here it is possible for plants to take advantage of the shade and litter that suppress grass growth.

Once safe sites are colonised by woody species opportunities for shade tolerant species are created. These plants frequently consists of rabbit-resistant species such as; poroporo, elder, flowering currant and tree nettle. It is important to note that unlike elsewhere in the island's vicinity, gorse and broom play minor roles. This is because of the weed control policy of the DoC management. The observed sequences have been summarised in Figure 3.21.

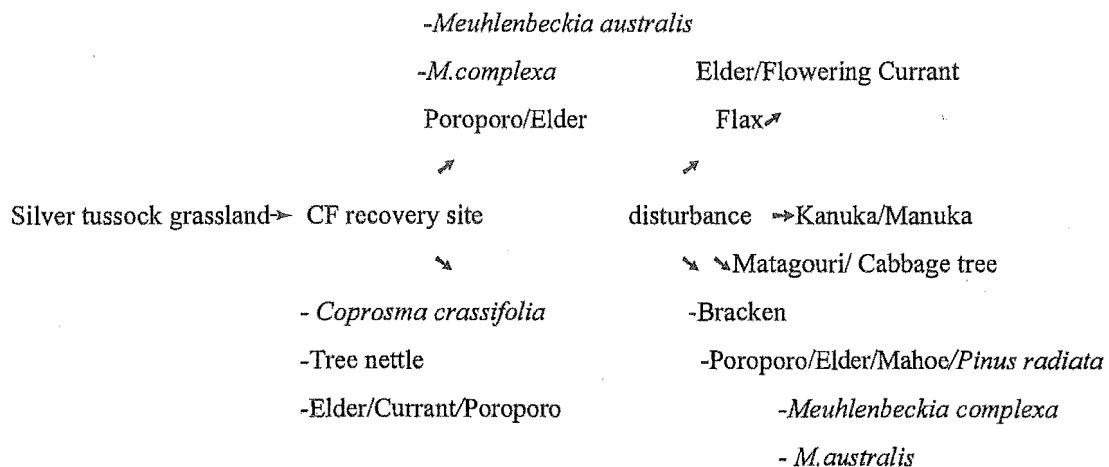


Figure 3.21 A summary of some common vegetation change sequences occurring on Quail Island.



Figure 3.19 Rocky outcrops and quarry rubble in the grassland matrix provide safe sites for species such as bracken, matagouri and *Coprosma crassifolia*. Southern beaches region, L/U#1.



Figure 3.20. Felled macrocarpa on the exposed northern plateau provides safe sites for poroporo, elder and flowering currant seedlings.

There has been very little spread of post-colonial transitional species into the modified old fields and quarantine paddocks (L/U#6 &3). This lack of advancement may be due to a variety of factors. The most important is likely to be the persistence of exotic perennial grass swards, which outcompete seedlings for both space and moisture. Secondly the general moisture limitation during times of seedling establishment which prove intolerable for some species. Thirdly, the prevailing northeast wind would make it difficult for wind dispersed matagouri, flax and bracken propagules to spread from the south to the north. Finally the availability of bare ground caused by slips and fire disturbance may be a major limiting factor. The northern plateau is rolling and gently sloping making it less prone to erosion and there is less chance of the development of slips as safe sites for colonisers such as kanuka.

Those sites that are successfully colonised by pre-colonial species are often the harshest sites with very little soil and high degrees of exposure. Here pre-colonial species appear to have a competitive edge over post-colonial species. For example *Coprosma crassifolia* often occupies the rocky ridge outcrops on the island. Inhospitable sites such as coastal rocky outcrop are frequently colonised by ahiraho (*Olearia paniculata*). Nevertheless more extreme sites may be beyond the limits of tolerance for some pre-colonial species in which case they are colonised by hardier post-colonials. For example boxthorn (*Lycium ferrocissimum*) and boneseed (*Chrysanthemoides monilifera*) are dryland specialists imported from the Mediterranean and South Africa respectively. They can be found on coastal rock outcrops without any soil beyond the reach of pre-colonial species. Boxthorn is uncommon on the island due to control by management. However boneseed forms the dominant vegetation of the northeastern cliffs (L/U#5)(Figure 3.27). This hardy plant is a native of the South African Fynbos, a form of dry shrubland. Fire is a major part of the fynbos ecology. Boneseed is not fire resistant, but being short lived (life span of 10 years) it is able to colonise sites after fire. In the absence of fire, the Fynbos is believed to be transitional to forest (Mandus *et al*, 1992). It is a subject for further research to determine the ecological role of boneseed and boxthorn in coastal contemporary forest development.

3.3.5 Vegetation change occurring on Mansons Peninsula (*Kaitangata*)

The purpose of this section is to interpret the vegetation change sequences occurring on Quail Island and to build up a practical and ecologically appropriate restoration pathway. To this end the more advanced vegetation change patterns occurring on the ungrazed steep coastal slopes of Mansons Peninsula were described.

Mansons Peninsula (*Kaitangata*) lies approximately 1.2 km south west of Quail Island (Figure 1.1). It exhibits significant CF recovery through broom, gorse and bracken. Quail Island and Mansons Peninsula are environmentally very similar, having the same geology, soils, altitude, aspect regime, a scarcity or absence of permanently flowing streams and subject to a similar seed rain. However the rainfall patterns on Mansons Peninsula differ from Quail Island. Mansons Peninsula extends approximately 1.5 kms into the Head of the Bay and it is bisected by two rainfall isohyets. The area between Cove 5 to the northern tip of the peninsula lies beneath the 800-900mm isohyet, while the area between Cove 5 and Cove 1, lies underneath the 900-1000mm isohyet (Figures 3.2 & 3.22). These rainfall patterns are reflected in the difference of the speed of forest recovery between the two sites, where the wetter areas recover at a faster rate than the drier ones.

Quail Island is drier than both the aforementioned areas, receiving between 700-800mm p.a. The effect of lower rainfall on Quail Island is that the development of broom and gorse cover and subsequent forest recovery would be correspondingly slower⁴ (*cf* McCracken, 1993). Nevertheless forest composition in the three locations should not differ, but it is likely that the relative abundances of species would. For example, a greater proportion of drought intolerant species would be concentrated in the southern areas, while drought tolerant species would be common in the northern dry zone.

⁴ Rabbit numbers are considerably lower than on Quail Island, scoring a '2' on the MacLean Scale (*pers obs*). Quail Island has a rating of '4' (Chapter 7.3.2; Appendix 5). This would also contribute to the apparent differences in the rates of forest recovery.

Mansons Peninsula was reportedly an important fortress or *Pa* site for the Ngai Tahu (Jackson, 1990). For this reason it was probably cleared of forest vegetation. It has been farmed since the early 1850s (Ward, 1851; Penny Mahy, pers com). Aerial photographs (1941) show that Mansons Peninsula suffered severely from erosion in the steep coastal zones. The erosion probably began after the peninsula was first burnt before it was stocked with sheep and cattle. Grazing on these steep areas was arrested sometime after 1941 resulting in a recolonisation of these steep coastal areas and slips.

On the moister southeast facing slopes of the coves, pockets of mixed native and adventive scrub and a few broadleaf colonisers, (such as mahoe, karamu and five finger (*Pseudopanax arboreus*)), were able to establish themselves. Broom and gorse appear to be the principal colonisers, spreading from southern facing disturbance sites southwards into the drier parts of the coves. From observations of aerial photographs it can be suggested that compared to the northwest side, the spread southwards on the southeastern side is noticeably faster and the resulting vegetation is denser. Evidence from aerial photographs suggest that slips occurred northwestern side at about the same time as those on the southern side. On the southeastern sides, slips developed in a north to south direction, progressively providing more sites for invasion by gorse and broom. Owing to the sequential development of slips (as observed from the sequence of aerial photographs) on southern side of the side of the peninsula a chronosequence of vegetation change can be drawn. On the southeast side of the peninsula there are two coves (#3 and #4 Figure 3.22) that have sufficient vegetation for comparison and a comparable aspect regime, with north/northeast, east and southwest faces. Taking each face of approximately equivalent aspect separately, a sequence of vegetation change emerges. For example the woody vegetation of the youngest north/northeast face of Cove #3 is compared with that of the older north/northeast in cove #4 and so on. As chronosequences cannot be drawn for the northern side in the same fashion, the general pattern of vegetation change is briefly described for each cove.

The survey method was qualitative. Aerial photographs, field reconnaissance, interviews with the landowner and published botanical surveys of the area were used. Previous

botanical surveys were conducted by Wilson (1992a) and Brown (1995). Four aerial photograph series were employed, they date from 1941(S.N. 165), 1973 (S.N.2634), 1984 and 1994(S.N.9381). For clarity and to provide a smooth flow of the chronosequence sequence the 1984 series is not described in detail.

Chronosequence for South East Side of Mansons Peninsula

i) North/northeast faces of Coves.

Cove #3.

1) The coastal landslips probably occurred 5-6 years ago. Gorse and broom are wind dispersed and were the first woody colonisers. Gorse appears to be slightly more dominant in the slip areas than broom, while broom is more prevalent on the grassy tracts. Tree lucerne (*Chamaecytisus palmensis*) is also wind dispersed and is occasionally found both on slips and grassland areas. This species has been planted as part of a restoration initiative by the landowner and it is spreading into slip areas on this side of the peninsula. Grasses are mainly browntop, cocksfoot, sweet vernal with some silver tussock (Figure 3.23).

Cove #4.

2) Aerial photographs reveal that before 1984 this area was predominantly pasture with minor patches of broom. It is likely that pasture slipped away around the patches of broom, and the bare earth was colonised by gorse. Gorse and broom provide cover for birds as well as a microclimate for bird dispersed propagules. Pohuhue (*Meuhlenbeckia complexa*) and poroporo are both present at this site.

E/SE faces of coves.

Cove #3

Site 1) Aerial photographs show that this site was colonised by broom 20-30 years ago and later cleared. The present stands of gorse, broom and bracken are probably no more than 10 years old. This central area of Cove #3 faces south east and would be wetter

than the neighbouring north eastern arm of the cove and consequently the vegetation is denser and more luxuriant. Broom is the dominant woody plant here. Gorse and bracken are secondary to broom and they share the coastal fringe. Above this coastal stand there is a grove of kanuka which probably predates the arrival of the broom. The largest is older than 55 years. Adjacent to this stand is a thicket of *Coprosma crassifolia* along with a solitary cabbage tree (Figure 3.25).

Cove #4

Site 2) Aerial photographs reveal that this site was colonised well before 1941 probably as a result of disturbance through erosion. The dominant cover is comprised of broom, and gorse is comparatively rare at this site. The beach is fringed with salt marsh ribbonwood (*Plagianthus divaricatus*) above which is a row of flax. Pohuhue (*Muehlenbeckia australis*) is common throughout and together with broom forms a very dense and moist cover. Through this vegetation there are occasional examples of *Coprosma crassifolia* with regenerating elder, mahoe and ngaio. Cabbage trees are also frequent, forming an "emergent" canopy above this scrub and seedling layer. Associated with this layer is a solitary mature lace bark (*Hoheria augustifolia*). Although there is no regeneration of this tree around the edge of its canopy are numerous examples of regenerating broadleaf colonisers such as mahoe, flowering currant and elder. Necklace fern (*Asplenium flabellifolium*) and Richard's shield fern (*Polystrichum richardii*) form part of the ground layer (Figure 3.26).

Once a dense cover of broom is established bird dispersed plants appear. The climber, pohuhue (*M. australis*) forms a dense and moist cover for seedlings. Flax, which is moisture loving and wind dispersed is able to establish. Flax attracts nectarivorous-frugivores (see Section 3.4) such as silvereyes (*Zosterops lateralis*), bellbirds (*Anthornis melanura*) and the omnivorous European starling (*Sturnus vulgaris*), all of which disperse the forest propagules into the scrub matrix. These species are common around the lacebark, indicating that it is probably an important perch site for fruit eating birds.

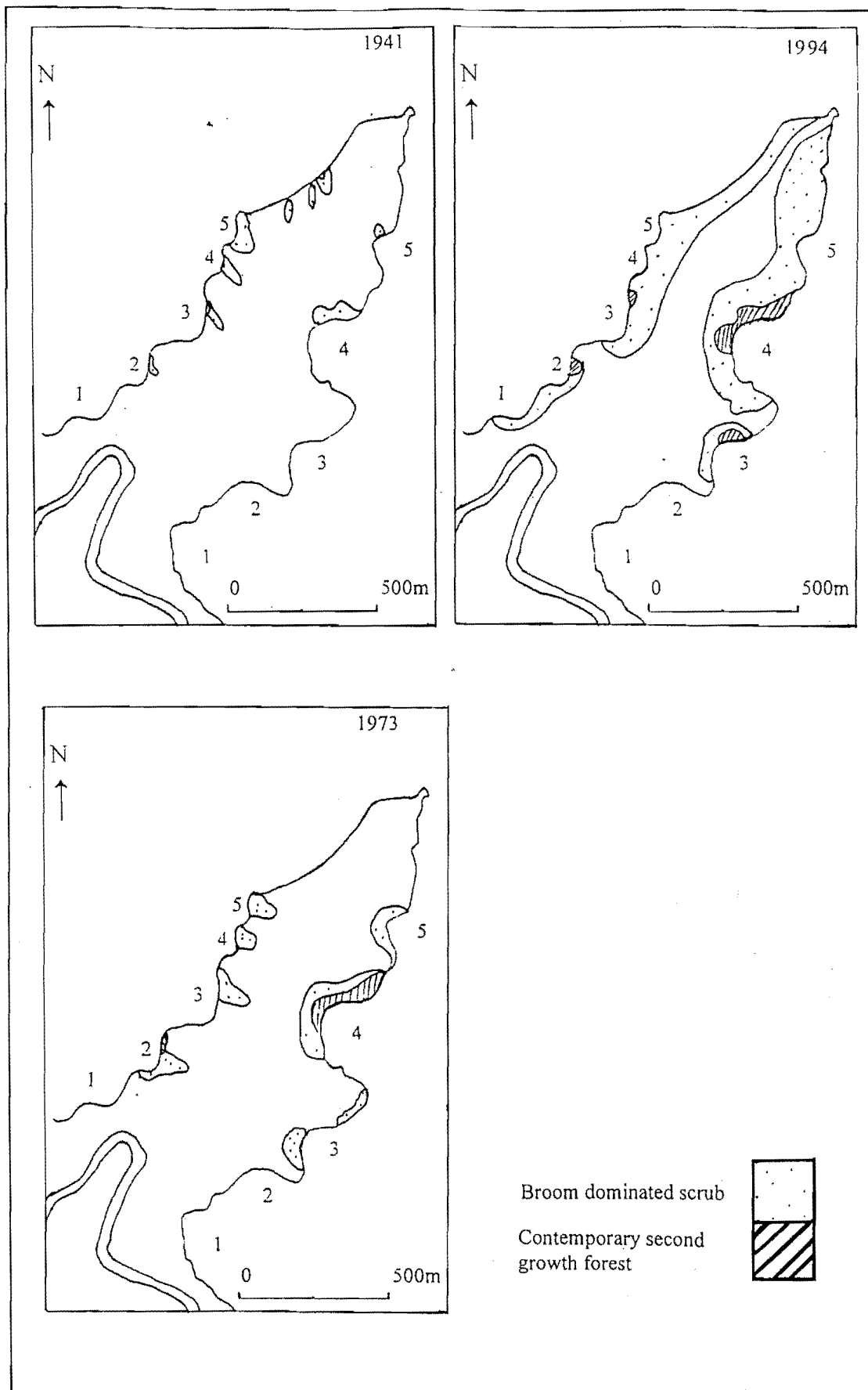


Figure 3.22 Mansons Peninsula vegetation change sequences, taken from aerial photographs from 1941 (S.N. 165), 1973 (S.N.2634) and 1994 (S.N.9381).

iii) Southwest faces of Coves.

Cove #3 Site 1)

It is likely that vegetation did not appear at this site until the early 1970s. In this small area there are two dominant woody vegetation types; a mixed gorse and broom cover and a very small fragment of coastal pre-colonial second growth forest. The latter is comprised mostly of red matipo, ahiraho with a solitary karamu. This stand comes right to the sea's edge and it has established on the volcanic bedrock. Along the sandy beach are two examples of salt marsh ribbonwood with a solitary cabbage tree (Figure 3.27).

Cove #4 Site 2)

Aerial photographs show that this site was well wooded in the early 1940s. The vegetation from the coast inland consists of a large stand of mixed kanuka, manuka and *Coprosma crassifolia*. The ground cover is made up of the common post-colonial grasses along with broom, flax and manuka and kanuka regrowth. Further inland there are large stands of cabbage trees and ngaio. Both pohuhue climbers are present.

Manuka and kanuka are usually able to colonise disturbance sites, however in this instance they have been confined to this enclave despite the incidence of erosion in other parts of the cove. It is likely that when slips occur they are outcompeted by gorse and broom. In the future it is probable that the broadleaf colonisers will overtop the gorse-broom matrix before the manuka-kanuka stand has time to spread (Figure 3.28).

Vegetation change on the northwest side of Mansons Peninsula

The earliest aerial photographs show that scrub and second growth forest existed in all the available southern facing coastal sites. It is possible that they are all of a similar age and result from the same period of erosion. As new slips occur the southern facing sides of the gullies are the first to be colonised. Woody colonisers spread outwards from these points. In general life on the northwestern side is harder than on the southeastern

side of the peninsula, this is reflected in the predominance of broom, gorse and fewer pre-colonial forest species. Furthermore, woody species diversity in the southern faces of coves steadily declines moving from the southern base of the peninsula to the northern tip. This may indicate the declining rainfall as one moves northwards up the peninsula. It is tempting to think that this pattern is indicative of a climatic tree line, but in reality it is probably due to the time lag in forest recovery in northern sites compared to southern sites

i) Southwestern sides

Cove #2, Site 1) This site receives the most rainfall of all the northern coves (900-1000 mm) and it is the only site that is truly sheltered from the north west wind. It shows the most pronounced second growth contemporary indigenous forest on this side of the peninsula. Manuka forms the canopy with scattered examples of ahiraho, five finger, *Coprosma crassifolia*, poroporo, cabbage tree and elder, all of which are regenerating in this site. This strip of forest descends to the seashore where saltmarsh ribbonwood becomes the dominant woody species. This vegetation is surrounded by a matrix of gorse and broom from which cabbage tree, poroporo and manuka are emerging. It can be assumed that the second growth forest vegetation will spread out into the matrix forming a complete canopy.

Cove #3, Site 2) Predominantly broom with scattered poroporo, cabbage tree, flax, and native broom (*Carmichaelia sp.*).

Cove #4, Site 3. This site is 95% broom with very little gorse. There are patches of poroporo and bracken along with three ahiraho shrubs (*Olearia paniculata*).

Northwest/west sides of coves. All the northern sides of coves are essentially a mix of gorse and broom and post-colonial grasses such as cocksfoot and sweet vernal. The only exception is the northern side of Cove #2, where poroporo, saltmarsh ribbonwood (*Plagianthus divaricatus*), pohuhue (*Muehlenbeckia australis*) are occasionally found.

Summary of Vegetation Changes on Manson Peninsula

The factor limiting the spread of woody vegetation on both sides of the peninsula appears to be the availability of disturbance sites and the distribution of moisture. On the northern side slips are more common, but owing to a scarcity of moisture colonisation is slower than on the opposite side of the peninsula. On the southern aspects bracken is frequently observed as a nurse species for mahoe and elder. Bracken is shorter lived than either gorse, broom, manuka or kanuka. This fern is uncommon on the northern aspects and it is broom and gorse that serve as nurse crops for pre-colonial species.

The northwestern slopes are less diverse than the west or southwestern slopes. Note that with the exception of cabbage tree and *M.complexa*, the oldest northwestern sites do not have significant stands of bird dispersed plants such as elder, ngaio, mahoe or flowering currant, which are common in the southwest sites. It would appear that if manuka and kanuka could out compete gorse and broom they would eventually dominate these dry aspects.

The vegetation on the drier parts of the peninsula (i.e. north of the 900-1000mm rainfall isohyet) are essentially monocultures of broom. The usual transition time to forest in these conditions is 25-30 years after the attainment of a gorse-broom canopy (McCracken, 1993). These have persisted for at least 7 years without showing signs of forest recovery. This may be due to a combination of the following factors: a scarcity of propagules, continued mob stocking of sheep and the browsing by hares and rabbits (Penny Mahy, pers com).

Unfortunately the sequence is not long enough to indicate the future vegetation of the northern aspects. Colonisation of these aspects by broadleaf forest species can only occur once a canopy of scrub is formed accompanied by a period of abnormally high rainfall and adequate supplies of propagules.

Unfortunately there are no comparative sites of northerly facing maritime, contemporary indigenous second growth forest, in the Lyttelton Harbour Basin available for accurate interpolation. General conclusions can be drawn from the CF recovery patterns occurring on the northwest sides of the Hoon Hay Valley in the Port Hills. The Hoon Hay Valley receives approximately the same rainfall as Mansons Peninsula (Figure 3.2) and has similar loessial soils. It is the opinion of this author that in this area, a mahoe dominated canopy may develop and over top the gorse-broom matrix. In this light it is conceivable that as the cover on the north/northeastern sides builds up and its capacity to retain moisture increases, and given an adequate supply of pre-colonial broadleaf propagules, it is likely that the vegetation of the north/northeast will eventually come to resemble that of the southwest.



Figure 3.23 N/NE face of Cove #3, Mansons Peninsula (June 1996)



Figure3.24 N/NE face of Cove #4, Mansons Peninsula. (June 1996)



Figure 3.25 SE face of Cove #3, Mansons Peninsula (June 1996)



Figure 3.26 SE face of Cove #4, Mansons Peninsula (June 1996)



Figure 3.27 SW face of Cove #3, Mansons Peninsula (June 1996)



Figure 3.28 SW face of Cove #4, Mansons Peninsula (June 1996)

3.4 Fauna

3.4.1 Invertebrates

No surveys of the invertebrate fauna of Quail Island have been done, although it is likely to be typical of coastal exotic pasture and mixed native-exotic scrubland. Overall the grassland community in Canterbury is not diverse, although relative abundance is very high (Harrison, 1969). Harrison (1969) observes that Canterbury's invertebrate fauna is noted for its large number of wide ranging species. These species are successful in grassland, scrub and forest at range of altitudes. This is borne out by Johns (1986) who observes that there is little altitudinal specialisation or significant difference between forest and scrubland arthropod communities. Furthermore Harrison (1969) asserts that in Canterbury there is a paucity of forest specialist species. In this light it is fair to say that forest and scrubland species are more or less interchangeable (Peter Johns, pers com). Space does not permit a review of expected invertebrate groups. For a full list of arthropod family groups found in the reserves around the Lyttelton Harbour Basin which are likely to occur on Quail Island refer to Harrison (1969) and Johns (1986).

3.4.2 Reptiles.

Quail Island supports on two species of reptiles, the Pacific gecko (*Haplodactylus pacificus*) and the brown skink (*Oligosoma zelandica*) (McIvor, 1970). The Pacific gecko is especially common in the rocky and grassy areas of the plateau (L/U#6) (John Watson, pers com; pers obs).

3.4.3 Mammals

The island plays host to six species of introduced mammals: the stoat (*Mustela erimeia*), ferret (*Mustela furo*), hedgehog (*Erinaceus europaeus*), rat (*Rattus rattus*), house

mouse (*Mus domesticus*) and rabbit (*Oryctolagus cuniculus cuniculus*). The stoat and ferret will prey on rabbits, rats and mice as well as lizards, insects, eggs and chicks. The hedgehog has been known to take young rabbits from their nests (Bull, 1969) although it is not thought to be a threat to native birds (Wilson, 1992a). A cat has been seen but it is now believed to have been killed after a rabbit poisoning programme (John Watson, pers com). Rat droppings have been found but no sightings have been reported. Mice can cause severe depletion of forest seed stocks (Bull, 1969). John Watson (pers com.) reports occasional plagues of mice. Stoat have been sighted and hawk killed ferret remains were found on the south eastern coast (pers obs).

3.4.4 Avifauna.

The bird communities on Quail Island can be divided up into coastal and land communities. Coastal species will have a minor affect on the process of forest restoration, however they add to the overall island experience. A list of coastal species that frequent the island is provided in Table 3.4.

The land communities are given the most attention. A checklist of landbirds found on Quail Island is provided in Appendix 3. Of the 23 land bird species about a third (6 or 8) can be counted as pre-colonial. All but the pipit (*Anthus novaeseelandiae*) are able to inhabit both early transitional and mature forest vegetation and can be thought of as transferable to forest habitat. When forest dominated the Lyttelton Harbour Basin these species probably exploited forest clearances and edges. They are all able to co-exist with mammalian predation. In this section pre- and post-colonial landbirds, mammals and reptiles have been grouped together into common feeding guilds. This allows the present fauna on the island to be viewed as a complete ecosystem and enables effects of the restoration process to be readily seen.

Table 3.4 Coastal birds present on and around Quail Island

Species	Location
Kingfisher (<i>Halcyon sancta</i>)	Occasional on mudflats and in the southern parts of the island
Waders: South Island pied oystercatcher (<i>Himantopus finchi</i>), Pied stilt (<i>H. leucocephalus</i>), Godwit (<i>Limosa lapponica</i>), White faced heron (<i>Ardea novaehollandiae</i>)	Occasional on mudflats and on foreshore above Southern Beaches (L/U#1)
Little black shag (<i>Phalacrocorax carbo</i>), White throated shag (<i>P. melanoleucos brevirostris</i> , Black shag (<i>P. carbo</i>) & Spotted shag (<i>Strictocarbo punctatus</i>).	Often seen on old warf (L/U#20 and on ship wrecks (L/U#8)
Gulls: Black billed gull, Red billed gull (<i>L. scopulina</i>), Black backed gull (<i>L. dominicus</i>)	Black billed gull is infrequent here although may be seen on the foreshore in L/U#1. Red billed gull is common throughout the coastal zones. The black backed gull has a colony on the north western tip of the island (L/U#7)
Terns: White fronted tern (<i>Sterna striata</i>)	Seen frequently in the vicinity of the island and roosting on old warf site.
Penguins: White flippered penguin (<i>Eudyptula albosignata</i>)(Banks Peninsula endemic)	Not seen on Quail Island the early 1980s. The island supported a small colony up to the early 1980s
Ducks: Mallard* (<i>Anas platyrhynchos</i>), grey duck (<i>A. superciliosa</i>) and hybrids	Frequent the southern beaches region, roost on the grassy foreshore.

3.4.5.0 Trophic relationships.

It is the purpose of this section to describe the island's vertebrate fauna in terms of community relationships. The community has been broken down into guilds, based on common resource use and irrespective of taxonomy or history. For example the post colonial ferret (*Mustela furo*), stoat (*Mustela erminea*) and the pre-colonial harrier hawk (*Circus approximans*) are put into the "large predator guild." All three rely on the rabbit (*Oryctolagus cuniculus cuniculus*) as a significant part of their diet. Competition is avoided through different feeding times and the level of dependence on the rabbit as

prey. Descriptions are qualitative and based largely on literature reviews and personal observation. One of the aims of this exercise is to suggest possible ecological relationships between post and pre-colonial species. It also serves as a faunal reference state against which success of the process of restoration can be monitored (Chapter 9). For example as forest recovery progresses and the area of grassland decreases, one would expect a decline in granivorous birds with an increase in nectivorous and frugivorous species such as the bellbird, silvereye and kereru (*Hemiphaga novaeseelandiae*). Furthermore a control of the rabbit population should result in falls in the mustelid and harrier hawk population.

Species were allocated to guilds based on their principal food source as described by Atkinson and Millener (1991), Bull (1985), Marshall *et al* (1972), King (1990). Guild categories were adapted from those used by Atkinson and Millener (1991). Owing to the wide range of food taken by most guilds are given composite names, with the most commonly exploited resource determining the major trophic level. For example the yellowhammer (*Emberiza citrinella*) feeds mainly on grain but will take insects during the breeding season, it is placed into the insectivorous-granivore category. This title is followed by a description of its chief mode of locomotion; for example, Flighted(F) or non-flighted (nf) and period of activity, nocturnal (N), diurnal (D) or crepuscular (C).

Proceeding this is a description of its food in order of preference and method of feeding. Finally there is a description of where it feeds and at what level above the ground. Lastly each species is categorised in terms of whether it is transferable restored forest habitat. The trophic relationships have been summarised in table form and presented below (Tables 3.5-3.14).

Table 3.5 Carnivores: Major predators of vertebrates .

Guild: Carnivores	Activity	Food/Method	Feeding level
Harrier Hawk (<i>Circus approximans</i>)	F/D	Passive predator. Feeds on : rabbit, carrion, invertebrates, small birds, rodents & insects	Takes prey from the ground from soaring position. Not transferable . Found throughout, mainly grassland L/U#6 .
Ferret (<i>Mustela furo</i>)	N	Active predator. Rabbit , rodents, birds, lizards, hedgehog and frogs.	From below ground to subcanopy. Transferable L/U #1.
Stoat (<i>Mustela erminea</i>)	D/N	Active predator. Birds, rodents, rabbits, insects, lizards, carrion	underground to the subcanopy Transferable. L/U#3

Table 3.6 Insectivore-carnivore

Smaller predators of vertebrates	Activity	Food/Method	Feeding level
Hedgehog (<i>Erinaceus europaeus</i>)	N	Active predator Insectivorous but will feed on any animal matter.	Ground level. Not transferable .
Ship rat (<i>Rattus rattus</i>)	N	Ground insects	Ground level to subcanopy. Transferable.
White backed magpie (<i>Gymnorhina tibicen</i>)	F/D	Passive predator: Insects, lizards, small Birds, carrion, mice, vegetable matter, peas, wheat	Prefers open country, prey taken from ground. Not Transferable. Frequent L/U#1.
little Owl (<i>Athene noctua</i>)	N/C/D	Active & passive predator. Catches prey on the ground, Small rodents, insects, digs for worms & eats carrion.	Prefers open country. Transferable to the forest edge.
kingfisher (<i>Halcyon sancta</i>)	F/D	Passive predator. Intertidal crustacea, insects, Lizards, mice, small birds	Ground to sub-canopy. Prefers open areas, estuaries as well as forest. Transferable. In all southern districts, especially L/U#1,9 & 10.

Table 3.7 Small arboreal insectivores

Small arboreal insectivores	Activity	Food/Method	Feeding level
Grey warbler (<i>Gerygone igata</i>)	D	Hawking, hovering . Small insects and larvae	Understorey - Canopy. Scrub, conifer plantation, native plantings Transferable. Found throughout esp southern areas. Avoids open areas. without trees or shrubs
Fantail (<i>Rhipidura fuliginosa</i>)	F/D	Hawking small flying insects	Ground-lower-upper conpy. Scrub, plantations native plantings. Transferable. As grey warbler.

Table 3.8 Small ground insectivores

Small ground insectivores	Activity	Food/Method	Feeding level
Pipit (<i>Anthus novaeseelandiae</i>)	F/D	Insects and some seeds	Open grasslands. Insects foraged taken from the ground. Not Transferable. Restricted to L/U#6 and north west coast.
Hedgesparrow (<i>Prunella modularis</i>)	F/D	Small invertebrates actively sought. Some seeds taken in winter.	Prefers ground cover, beneath hedges, pine plantation. Transferable. May be restricted to L/U#1.
Brown skink (<i>Oligosoma zelandica</i>)	nF/D	Insects	Open country, crevices

Table 3.9 Insectivores-
Granivores

Guild	Activity	Food/Method	Feeding level
Skylark (<i>Alauda arvensis</i>)	F/D	Seeds, grass and insects	Open farm and grasslands. NotTransferable. Restricted to L/U#1.
Yellowhammer (<i>Emberiza citrinella</i>)	F/D	seeds, insects	Inhabits areas with more scrub vegetation, notably bracken, broom and gorse.
Goldfinch (<i>Carduelis carduelis</i>)	F/D	seeds and some insects	Feeds on seeding herbs. Common in annual meadow grasswards. NotTransferable Found throughout southern districts
Chaffinch (<i>Fringilla coelebs</i>)	F/D	seeds, insects.	Plantation area. Transferable. Found throughout southern districts

Table 3.10 Granivore-
frugivore-insectivore guild

Granivore-frugivore-insectivore	Activity	Food/Method	Feeding level
Greenfinch (<i>Carduelis chloris</i>)	F/D	Seeds, fruit and some insects.	Forest margins , pine forest, shorelines, boxthorn. Ground, scrub arboreal. Not Transferable. L/U#1
Redpoll (<i>Carduelis flammea</i>)	F/D	Seeds, fruit and some insects.	Scrub, similar habitat to goldfinch. Not Transferable. Southern districts.

Table 3.11 Worm eating- frugivore-insectivore

Worm eating- frugivore-insectivore	Activity	Food/Method	Feeding level
Blackbird (<i>Turdus merula</i>)	F/D	Worms, fruit, insects	Feed predominant on the ground, scrub, forest litter, subcanopy in search of fruit. Transferable. Throughout.
Song Thrush (<i>Turdus philomelos</i>)	F/D		Not Transferable. L/U#1
Starling (<i>Sturnus vulgaris</i>)	F/D	Worms, grassgrub, insects fruit, flax nectar	Ground, coastal cliffs, open grassland. Transferable. Frequent throughout.

Table 3.12 Nectarivores

Nectarivores	Activity	Food/Method	Feeding level
Bellbird (<i>Anthornis melanura</i>)	F/D	Nectar, honey dew, fruit, insects.	Trunks of trees, branches, mixed scrub, some exotic forest, native plantation. Transferable. Rare visitor L/U#
Silvereye (<i>Zosterops lateralis</i>)	F/D	Insects, nectar, fruit.	Scrub, native plantation, glean, hover, ground to subcanopy. Transferable. Throughout mainly southern districts.
Common gecko (<i>Haplodactylus pacificus</i>)	nf/D/C	Insects, nectar, fruit.	Ground crevices, intertidal, grassland, scrub and bush (McCann, 1955 p.44)

Table 3.13 Granivore-herbivore guild

Granivore-herbivore	Activity	Food/Method	Feeding level
Californian Quail (<i>Lophortyx californica</i>)	F/D	Seeds, soft grasses, fruit.	Ground level, scrub, bracken, plantation. Not Transferable. L/U#1 & 9

Table 3.14 Herbivore guild

Herbivore	Activity	Food/Method	Feeding level
Rabbit (<i>Oryctolagus cuniculus cuniculus</i>)	D/C/N	Grass, roots, foliage, fruit.	Ground level, dig for roots, take lower foliage. Not Transferable. Common throughout.

3.5 Summary and Conclusions

The island's biota is a mix of pre-colonial and post-colonial indigenous communities. Nine plant communities and nine terrestrial vertebrate guilds are recognised. Invertebrates were not dealt with in detail, except to note that the current scrub and grassland species composition is unlikely to change after forest restoration. Together these communities reflect the interplay of past and present natural and cultural forces. It is impossible to completely separate out these influences, as each one effects the other to some degree. Nevertheless it is possible to prioritise their affects in terms of a series of coarse to fine environmental filters. For example the general type and nature of human activity, along with the faunal and vegetation patterns on the island are firstly determined by the island's bioclimatic zone. This determines the type of agriculture that can be practised, what species can be successfully naturalised and the type of forest that will recover given a cessation of disturbance regimes and extirpation of stressors. Topography and aspect operates as a second level filter determining the pattern of forest recovery as well as the positioning of shelter belts and amenity trees. Both these factors determine the diversity and distribution of vertebrate species.

On Quail Island there are probably currently three categories of fine filters operating:

- i) The coarse meshed filters (Filters 1A, 2A and 3A) operating over the island can be considered to be the influence of climate, the island's microclimate and soil fertility (Figure 3.31). These may be thought of as determining the island's bioclimatic zone. This is followed by medium meshed filters (Filters 1B, 2B and 3B) such as the influence of salinity together with proximity to the sea, aspect and shelter from wind (Figure 3.29). Together these factors determine the island's microclimate in comparison to the rest of the Lyttelton Harbour Basin and Mt Herbert Ecological District. The finer meshed filters (Filters 1C, 2C, 3C and 4C) operate within the former two and can be regarded as the following: availability of seedling safe sites, ability to be dispersed, drought tolerance and palatability (Figure 3.29).

The three levels of filters are further summarised below.

In the beginning of this chapter I proposed that the "lowland maritime bioclimatic zone" described by Wilson (1993) could be divided into humid and sub-humid subzones. The former is located at the eastern tip of Banks Peninsula while the latter follows the coastal 700-800mm isohyet around the rest of the Peninsula. Quail Island is situated beneath this isohyet and can be placed into the subhumid component. Although it is not known whether species composition differs between these components, forest recovery probably occurs at a comparatively slower rate under sub-humid conditions. The antecedent vegetation likely to have occupied this zone was a maritime variant of a matai-lowland totara-kahikatea mixed coastal hardwood forest, with coastal shrubland in drier aspects (Chapter 4.2.2).

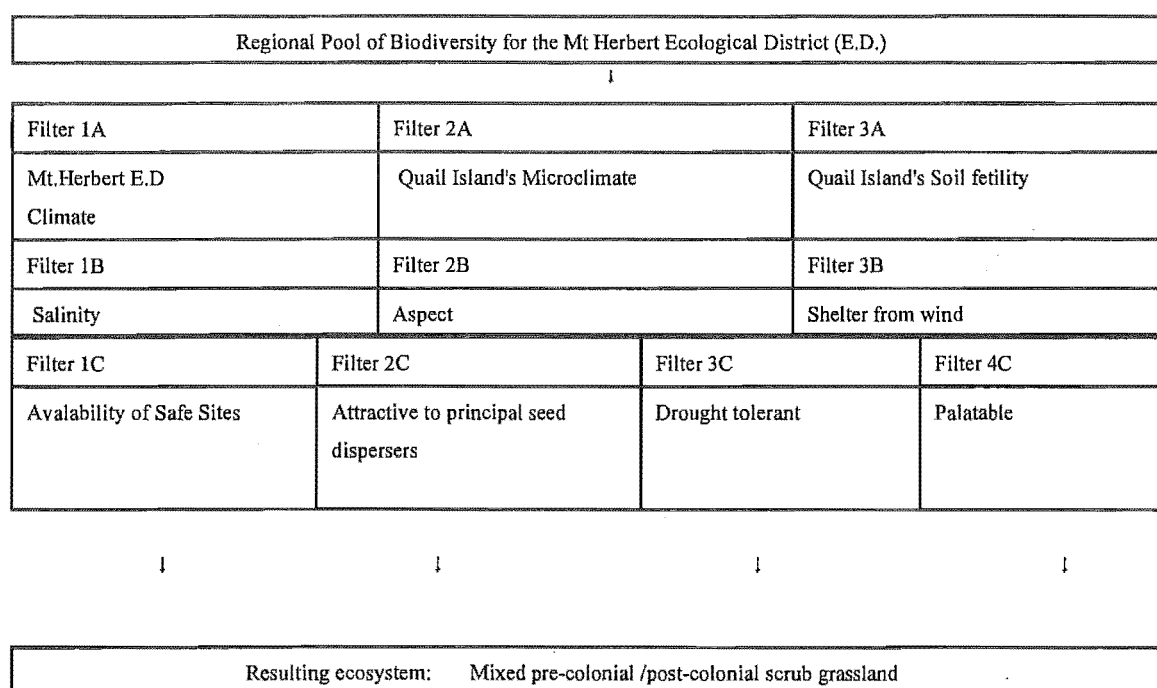


Figure 3.29 A conceptual representation of the prevailing environmental filters which determine current species composition on Quail Island.

The island's topography and local climate operate as the second level and finer environmental filter. Together they select out where and how communities re-establish

after disturbance. The island's climate not unlike that of the rest of Banks Peninsula is governed by the interplay of southerly and northerly frontal systems. Northern aspects are dry and sunny while southern aspects are cool and shady. The distribution of northern and southern aspects is determined by the island's topography, which is in turn determined by the island's complex geological history.

Aspect has a profound effect on the pattern of naturally occurring woody transitional forest vegetation on Quail Island and throughout Banks Peninsula. Pre-colonial woody colonisers are concentrated in southern facing landscape units as well as southern or particularly sheltered and moist landforms within the northern landscape units. For example bracken, matagouri, *Coprosma crassifolia*, manuka and kanuka are restricted to these sites on the island, although forest recovery is occurring at the freshwater seepage point below the north east cliffs (L/U#5). Within these cooler and wetter places woody colonisation is usually restricted to breaks in the grassy matrix. Such sites have been termed "forest seedling safe sites." Nine safe sites have been recognised. Their availability and distribution constitutes a further selection force and can be regarded as the third environmental filter in operation on Quail Island. The effect of aspect on mature forest on Banks Peninsula has not been studied, however it is likely that owing to the greater moisture retention in southern aspects, species density would be greater here than in the north (Chapter 4).

The success of recolonisation by woody plants of safe sites is ultimately determined by their accessibility and palatability to rabbits. Establishment of palatable seedlings such as *Hebe salicifolia* and red matipo (*Myrsine australis*) may only occur in accessible areas during periods of low rabbit numbers usually after a poisoning programme. Rabbit browsing may be considered the fourth environmental filter. Those woody species considered by the DoC management as non-indigenous are selectively removed; this action may constitute a fifth level filter. It is evident that the control of the two latter filters would significantly accelerate the natural forest recovery processes occurring on Quail Island.

Chapter 4 :

Ecological Restoration Reference States for Quail Island (Otamahua)

4.0 Introduction

The purpose of this chapter is three fold. Firstly to describe Quail Island's possible pre-settlement forest vegetation and avifauna. In the preceding chapter it was proposed that Quail Island has a forest environment and if the environmental stressors could be removed a "contemporary forest" would probably develop. At this point I would postulate that it is unlikely that the island has only recently become a forest environment, but has been one for many thousands of years. From this point I outline what is known about the extent of forests in the Lyttelton Harbour region and in sites environmentally analogous to Quail Island in pre-settlement times. Secondly it is the aim of this chapter to explain why the island's forest was cleared and thirdly to set up restoration reference states which will serve as guides for the restoration process (Chapter 8) and finally to provide baselines for monitoring (Chapter 9).

The composition of the restoration species pool for Quail Island is derived from a range of natural restoration reference states. Nine reference states are recognised. They range from pre-settlement forest vegetation, old growth, second growth forest, old field treeland and scrubland and cover the pre-settlement, colonial and contemporary time periods. Methods for reconstructing the character of the pre-settlement vegetation are discussed in Section 4.2.1. A description of this vegetation along with the likely avifaunal communities is given in Section 4.2.2-4.2.11. In the final section I summarise and draw out the main findings of this chapter. It must be noted that the descriptions of pre-settlement, pre-colonial and colonial forest and avifauna are speculative.

4.1.0 The extent of Pre-settlement Forest Vegetation

In pre-settlement times there were very few areas in New Zealand that were below a climate tree line. In most cases the country was almost completely covered in continuous tall forest and/or tall shrub land. Central Otago is considered to be the only major exception. It is otherwise generally agreed that ancient short and tall tussock grasslands in pre-human days were confined to harsh and disturbance prone sites, such as river flood plains along stream banks, frost flats and disturbance areas in forests (McGlone, 1983). It is believed that almost all of the Lyttelton Harbour Basin, from the seashore to the crater rim was covered in mixed broadleaf podocarp forest (Ogilvy, 1990; Wilson, 1992). Lilley (1990) maintains it was only the excessively steep or very wet areas that could not support forest. Wilson (1992a) asserts it was only certain very exposed headlands and high altitude outcrops that were not forested. The more gently sloping ground was taken up by dense podocarp forest, and the steep and rocky bluffs were the few niches open to grasses such as *Chionochloa rigida*. In this light it would seem unlikely that Quail Island was not also forested.

Historic records show that sites environmentally analogous to Quail Island were forested. For example, forest distribution maps for the Lyttelton Harbour Basin from 1850 (compiled by Thomas (1989) Figure 4.1) and for the rest of Banks Peninsula from 1860 (compiled by Petrie (1963) Figure 4.2) were overlaid with the New Zealand Resource Inventory Maps of Banks Peninsula. Those land units similar to Quail Island and possessing forest cover in the years of 1850 and 1860, suggest that it is possible that a similar forest could have existed on the island. For example locations such as Rapaki, Puari at Port Levy, the head of Pigeon Bay, Long Lookout Point, inland above Menzies Bay, between the eastern side of Okains Bay, Decanter Bay and Southhead were all covered in old growth mixed podocarp-broadleaf forest and are environmentally similar to Quail Island. Further more although barren at the time of colonisation, it is very likely that the site of the Oruaka Pa, on the northwestern side of the mouth of Lake Forsythe was also forested in pre-settlement times (Wilson, 1992a). Lake Forsythe has only recently become a lake. In the early nineteenth century it was open to the sea and

used as a harbour (Kirk, 1994). The forest was probably subjected to the desiccating effects of the nor-wester as well as exposure to salt spray. It is likely that conditions were just as harsh as on the north western sides of Quail Island. In this light it can be assumed that if forest existed in this location it could also have existed in similar localities on Quail Island.

4.1.1 The Impact of Polynesian Settlement on the forests of the Lyttelton Harbour Basin.

The earliest Polynesian settlers are thought to have arrived in New Zealand between c.2000 and 1000 years BP (McGlone,1983; King, 1989). The dominant vegetation that occupied Whakaraupo (Lyttelton Harbour) would have been extensive, dense and dry mixed broadleaf-podocarp forest. The majority of Quail Island was probably covered in this type of forest, with tall shrubland occupying only the harshest and driest north facing sites.

Fire was the principal land management tool used by the early Polynesians. It was utilised for clearing land for the cultivation of sweet potato or kumara, the semi-cultivation of bracken, for overland navigation, the establishment of settlements and for strategic purposes. Coastal regions were favoured for most of these activities (McGlone,1983) resulting in the clearance of nearly all of the forest in the maritime lowland bioclimatic zone (Chapter 3.1).

The use of fire, coupled with the fact that the climate had become drier, meant that forests were very susceptible to fire. In the light of this it would not be hard to imagine deliberate fires spreading out of control (McGlone,1983). Maori legends speak of huge conflagrations known as the "Fires of Tamatea" that are thought to have been responsible for the destruction of most of the Canterbury forests. The legendary hero, Tamatea is thought to have caused the accidental destruction the forests in the vicinity of Rapaki (Couch,1987). The readiness in summer of the forest to burn with the

slightest provocation is borne out in several testimonies of early European colonists (Adams, 1850). Approximately one third of the total forest cover of Banks Peninsula was destroyed during the period of Polynesian occupation (Wilson, 1992a).

The first Europeans arrived in Whakaraoupo in the early 1830s; they were the whalers, sealers and flaxtraders (Thomas, 1989). From accounts taken from their journals, the harbour basin was only partially forested, Rapaki was the only wooded area of any use to the settlers for timber (Wakefield, 1848) (Figure 4.2).

Owing to Quail Island's climate, soils and strategic location, it is possible that the island was used by the Maori for strategic purposes as well as for the cultivation of kumara and other vegetable crops. For these reasons the island would have been cleared of woody vegetation and this is the likely explanation for its barren appearance at the time of the European arrival. It is known that kumara requires forest soils to be successfully cultivated (Best, 1925). The nearest recorded plantations were at Rapaki, but kumara was grown with some difficulty there (Tikao and Beattie, 1983). Quail Island with its mild and frost free climate and its reputation for good growing potential (Sisson, 1978; Jackson, 1990) may have been conducive to successful kumara cultivation. Puari in Port Levy is edaphically and climatically comparable to Quail Island and was the site of the largest kumara plantations on Banks Peninsula (Shortland, 1851). Up to 1860 it supported a large expanse of mixed podocarp/broadleaf forest (Figure 4.3). The suitability of Quail Island for the cultivation of kumara is an indication that forest may have existed previously on the island.

This supposition was born out in the comments made to me by June Swindells, the secretary for the Rapaki Runanga. According to information passed on to her by her grandfather, kumara was being cultivated on the island by the Ngati Mamoe at the time of the Ngai Tahu invasion of Whakaraoupo. Hitherto there is no written record of this and no archaeological research has been carried out to determine the significance the island had for agriculture.

At the time of the beginning of the colonial period Quail Island was unoccupied. There was however a Maori house or *whare*, located on the north west coast, this was used for overnight food gathering expeditions (Jackson, 1990). Jackson (1990) attributes the absence of any major settlement on the island to a scarcity of water and firewood. An alternative explanation may relate to the inter-hapu feuds¹ that decimated the Ngai Tahu in Banks Peninsula in the early 1800s before the arrival of the European (*cf* Ogilvy, 1990). Such feuds would have left the island deserted, although this has yet to be confirmed.

4.1.2 Early Written Records of Quail Island

The earliest chart of Lyttelton Harbour dates from 1844 and was drawn by J.M.Fournier of the French ship *Heroine* (Maling, 1981). On arrival it was the Ngai Tahu who greeted them. Fournier cites Quail Island as "*Te Kawakawa*", a name given by the preceding Ngati Mamoe tribe. This name has three possible derivations, all of which give clues to the nature of the island's original vegetation and/or its cultural importance.

Firstly it may have been named after the subcanopy coastal shrub kawakawa (*Macropiper excelsum*) thought to have been present on the island². *M. excelsum* was valued by the Maori for its medicinal properties (Brooker *et al*, 1987). Secondly it may be derived from the word "*kawa*" which describes the way the island rises up from the sea (Jackson, 1990). Finally the name "*kawakawa*" has denoted a so-called native gourd otherwise known as "*hue*" (Best, 1925), which may have been cultivated on the island. The kawakawa described by Best (1925) is thought to have been imported originally to the Marlborough Sounds during the mid 18th century by Captain James Cook (Brooker *et al*, 1987). The Ngai Tahu who succeeded the Ngati Mamoe renamed the island "*Otamahua*", which is said to mean "the place where children gather sea bird

¹Hapus are smaller divisions of the iwi or tribe. Inter-hapu feuds refers to conflict between these tribal sub-groups.

² Molloy(1978), Burrows(1983) and Wilson(1991) record a small remnant on the North East side of the island although I have been unable to find any trace of it

eggs" (Jackson,1990).

The first European to set foot on Quail Island was Captain Willian Mein Smith in 1842 of the schooner *Deborah*. He noted several native quail (*Corturnex novaezelandiae*) from which Mein Smith derived the island's English name (Wakefield, 1848). The vegetation cover is believed to have been predominantly grassland with scattered matagouri scrub and cabbage trees (Ward,1850; Laing,1919; Jackson,1990).

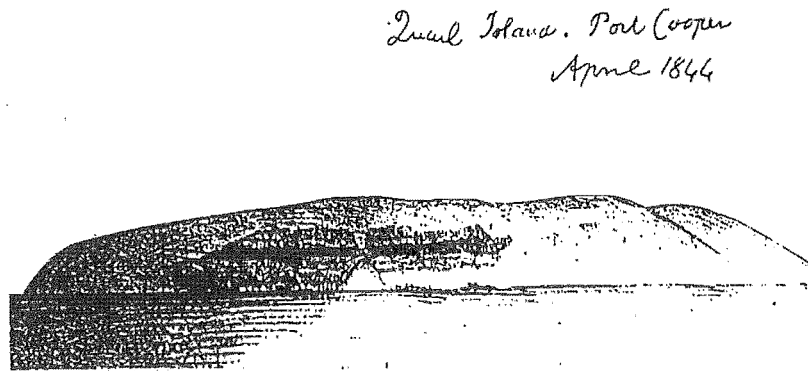


Figure 4.1. The earliest detailed sketch of Quail Island was made in 1844 by John Wallis Barincoat (Maling,1981). The striking feature of the island is the apparent absence of any obvious woody vegetation.

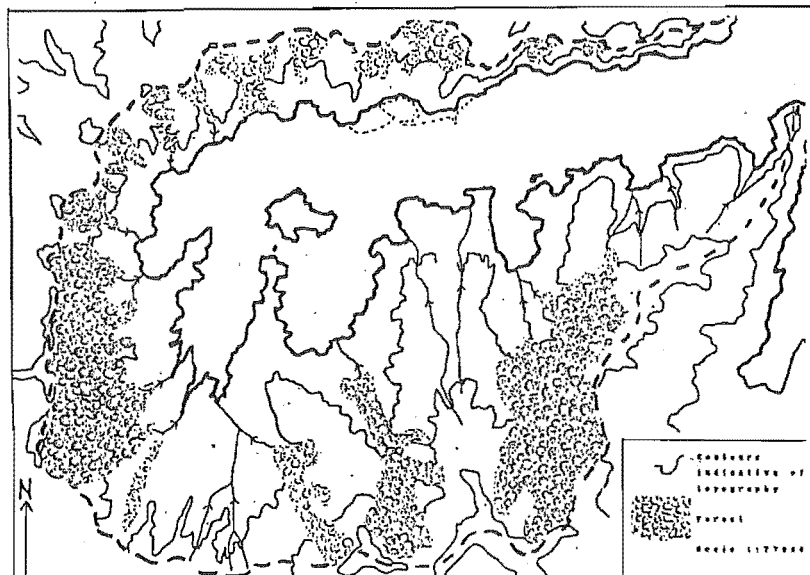


Figure 4.2 Map of the most likely forest distribution for the Lyttelton Harbour Basin from 1850 after Thomas (1989).

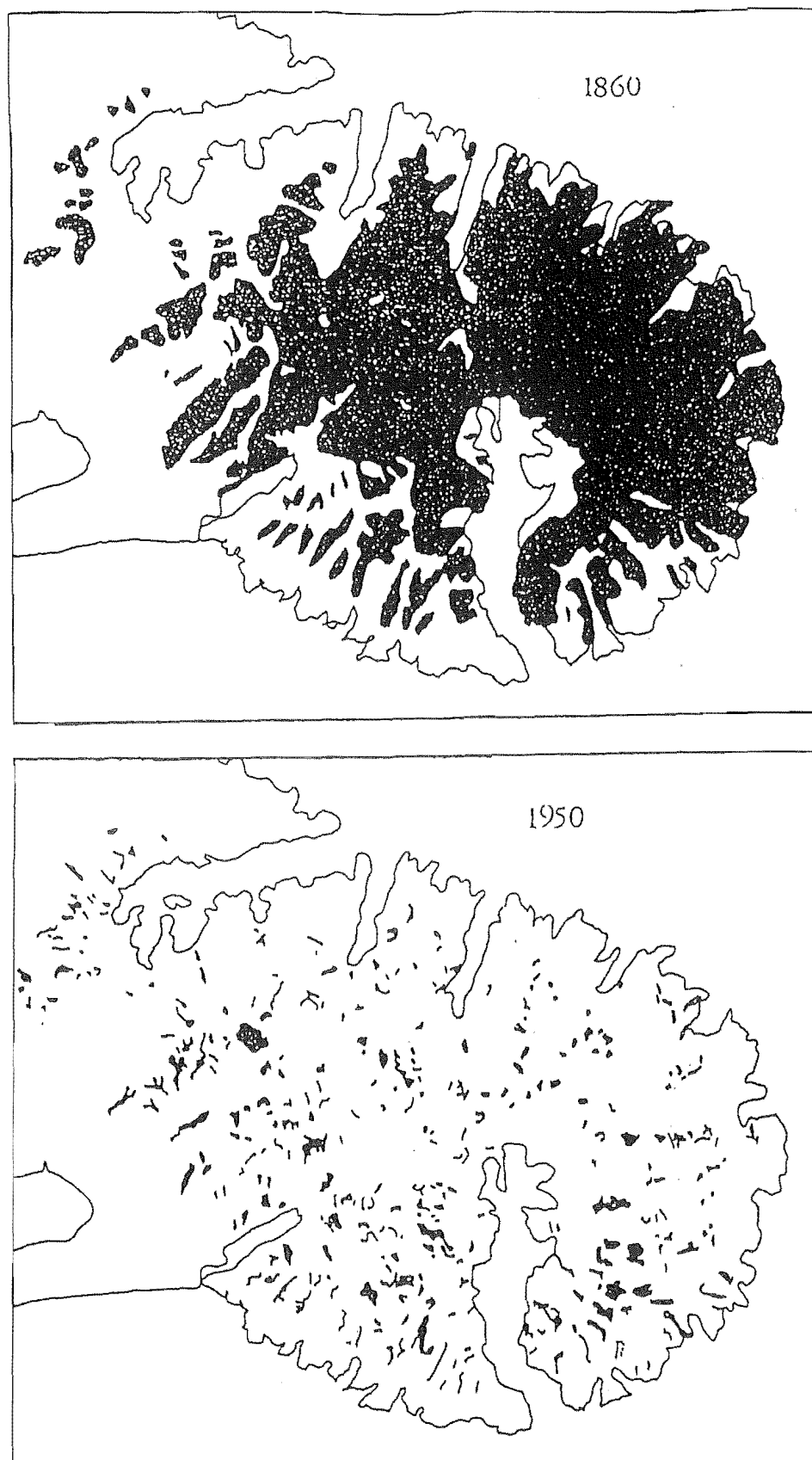


Figure 4.3 Forest distribution on Banks Peninsula from 1860 and 1950 after Petrie (1963)

4.2.0 The Restoration reference states

For the purposes of this concept plan restoration reference states have three purposes.

Firstly they provide a list of ecologically appropriate species suitable for use during restoration. As equal proportions of each species should ideally be used in the creation of species pools for the process of restoration, species' distribution and estimated relative abundances are unnecessary and have not been calculated. However owing to the natural abundance of some species and the scarcity of others (Rabinowitz, 1981, O'Conner *et al*, 1990) and as some species are more difficult and more expensive to cultivate than others, it may be impractical to ascertain even number of each species for compilation of species pools. This is discussed further in Chapter Eight. Secondly reference states provide baseline information for monitoring long term changes in vegetation and wildlife. Thirdly they may serve as baselines for determining the success of restoration projects.

Three general reference states are recognised: old growth forest, second growth forest and scrubland/ treeland representing three phases towards forest recovery. As there is an ethical obligation to restore pre-colonial and pre-settlement biodiversity where it is practical (Chapter 2.4), it was considered necessary to deduce and examine reference states from each of these growth phases. Further this highlights the changes in community structure and function, while showing up resource opportunities in the expected restored contemporary forest. Thus a total nine reference states were recognised. For example the extant species (ie locally extinct species) found in the antecedent ecosystems but not in contemporary ecosystems were "earmarked" for translocation to the restoration species pools. Species that were rendered completely extinct during the pre-settlement and colonial periods were examined in relation to adventive species. The purpose of this was to see to what extent the antecedent functional roles of extinct species would be continued by post-colonial species.

In most instances there are no clear records for the antecedent states or even undisturbed living representatives for the contemporary states notably of old and second growth

forest. For this reason vegetation reference states have been described in terms of the character of the vegetation. These character profiles are montages made up from species lists from sites that are environmentally comparable to Quail Island. In the case of the pre-settlement vegetation, where no clear model exists, this reference state will be partly determined by the outcome of the environmental filtering process. However without an accurate picture of the antecedent forest, determining how far the restored ecosystem diverges from the pre-settlement state is a matter for speculation.

The bird communities associated within each vegetation phase provide lists of ecologically appropriate extant species available for consideration for translocation. The examination of pre-settlement and colonial communities indicate the resource opportunity gaps left open through total extinctions of species such as the moas and large predators. These available resources may be partially exploited by introduced species, for example the blackbird may partially exploit opportunities left open through the loss of the piopio and the saddleback. The resources may remain unexploited until the advent of new species through immigration or evolutionary radiation.

Very little is known about the former diversity and distribution of the reptile fauna of Banks Peninsula. It is however known that many species are very sensitive to changes in their environment (Pickard and Towns, 1988; Towns and Daughety, 1994) and it is likely that this fauna has been considerably reduced. In order to limit the amount of speculation only those species known to exist in the region (four species) but do not occur on Quail Island have been considered. The forest dwellers are the jewelled gecko (*Haplodactylus gemmeus*), *H.granulata* and the spotted skink (*Leiopisma lincoocellatum*), followed by the common gecko *H.maculatus* which prefers open country. These have been included in the the discussion of the avifauna reference states.

These reference states may be thought loosely as a chronosequence comprising three or four frames. Before continuing a brief word concerning the usefulness and relevance of chronosequences to the restoration process should be given. Chronosequences are often intended to represent a future vegetation pathway by taking the oldest stand as the

probable future out-come of a vegetation change sequence starting from the youngest disturbance/ recovery site. In the Quail Island context the environment and the pre-colonial recovery processes are vastly different from the past. The attainment of a pre-historic condition is usually an impossibility owing to the permanence of some environmental changes. In reality the use of several different aged stands represents only a historical sequence from the past to the present, and not a sequence of the present to the future. The present recovery condition is heading to a mature form or metastasable state of which the final composition, function and structure can be only estimated. Chronosequences were also criticised by Picket (1989) in his "space for time " argument. Here he argued that site conditions and history must be more-or-less identical if an expected sequence of change can be drawn. Nevertheless if chronosequences are used with care a general model of vegetation change can be drawn (Burrows, 1991).

4.2.1 Reconstructing the likely pre-settlement forest vegetation of Quail Island

There are a number of methods that can be used to determine pre-disturbance vegetation. No one method is considered sufficient and the eclectic approach as recommended by Noss (1985) is used here. Of the methods available the five most suitable were investigated to see if they could be applied within the time and resources constraints of this thesis. These were as follows: i) the use of remnant forest stands in sites environmentally analogous to Quail Island, ii) the use of relict and isolated forest trees, soils, subfossil timber, fossilized pollen grains and phytoliths, iii) historical evidence and indigenous peoples knowledge of the native vegetation, iv) the personal knowledge of experts and finally v) the interpolation from landscape-vegetation relationships. The results of investigations are presented below. Of these techniques the latter was regarded as the most useful. The use of sub-fossil material was not pursued as there was a high risk that results would be inconclusive revealing less than what could be deduced from landscape-vegetation interpolations. However where the other three could be employed, the results were used in concert with method v).

i) Remnant Forest Stands.

No old growth stands exist on Quail Island, however remnant second growth forest species and forest recovery processes are present and active (Chapter 3.3.5)

ii) Relict isolated trees

The mature examples of ngaio (*Myoporum laetum*) and broadleaf (*Griselinia littoralis*) found below the seepage point on the north eastern cliffs L/U#5 (Figure 3.16a) are the largest and probably the oldest pre-colonial forest trees on the island. It is unlikely that they are relics but relatively recent arrivals dating from sometime after the European settlement (Chapter 3.3.1.6)

iii) Historical evidence, indigenous peoples knowledge of native vegetation.

The Ngai Tahu at Rapaki have no recollection of forest ever being on the island.

iv) The interpolation from the landscape-vegetation relationship and v) Detailed personal knowledge of indigenous flora.

These techniques were considered the most practical for deducing pre-settlement vegetation for Quail Island. Remnants for restoration reference sites should ideally be relatively undisturbed and located in the same bioclimatic zone. They should also have similar environmental attributes of slope, aspect, exposure to wind and wind carried salt, soil type and moisture regime. Comparable sites were sought by overlaying the distribution of coastal bush fragments (such as Figure 4.3) on the New Zealand Land Resource Inventory (N.Z.L.R.I) maps for Banks Peninsula. Sites comparable to the island were located by finding a match for the island's NZLRI code and Land Use Code (L.U.C).

The botany of Banks Peninsula is well recorded in the literature. The chief references used were the botanical surveys of the reserves of Banks Peninsula by Kelly (1972) and

the surveys conducted between 1987-90 by Hugh Wilson as part of the Banks Peninsula Protected Natural Area programme. In general these were used in concert with qualitative field observations.

Unfortunately comparable extant old growth forest matches for Quail Island on Banks Peninsula and most of the east coast of the South Island are now very scarce, very small and quite damaged by mammal browsing. The understoreys are depleted of palatable seedlings such as seven finger and ferns (Wilson, 1992a). Protected old growth forest remnants on Banks Peninsula are found outside of the island's "lowland maritime" bioclimatic zone. For this reason it was necessary to combine species composition from "maritime cool temperate" and "lower cool temperate" bioclimatic zones (Figure 3.2). Those species present in the lowland forests but considered unable to survive in a maritime climate were eliminated, while those species believed to be excluded by mammal browsing were added to the species lists. Added to these lists are observations and lists of species from the Lyttelton Harbour Basin such as the Governors Bay, Sandy Bay and Hunters Reserve (Figure 1.3).

The following coastal forest fragments sites were selected. North West Bay near the head of Okains Bay, Tipparary is located between Port Levy and Pigeon Bay and Ngaio Point on the north western side of Akaroa Harbour. Two "lowland" reserves, the Ahuriri Bush was selected (Figure 1.1). Finally coastal forest remnants from areas climatically equivalent to Banks Peninsula such as Gore Bay, south of Kaikoura may provide clues to the old growth composition of Quail Island. Lastly species were also drawn from a checklist of species native to Rapaki compiled by Hugh Wilson (1995).

North West Bay is located at the mouth of Okains Bay (Figure 4.4). This fragment covers 35ha and is located on the southern slopes of North West Bay between sea level and 160m. This is the only remaining forest fragment found under the 700-800mm rainfall isohyet and covering the altitudinal range of Quail Island. It supports a wide range of ecological classes from old growth mixed podocarp forest to coastal

tussockland. It consists of 1% matai-lowland tatara-kahikatea/mixed hardwood forest, 50% mixed broadleaf second growth hardwood forest and 10% kanuka dominant second growth hardwood forest. The remaining 39% is mainly scrub and pasture land. There is a grove of wild karaka indicating its former importance as a settlement for the Maori (Wilson, 1992a).

Tipparary is located between Port Levy and Pigeon Bay. It slopes gently towards the south east and lies between 340m-420m asl. Soils and rainfall are very similar to Quail Island. It is a small (6 ha) but significant forest fragment. 80% of this remnant is old growth matai-lowland totara-kahikatea/mixed hardwood forest, while the rest is mixed broadleaf second growth forest (15%), treeland (3%) and pasture (2%). Unfortunately this fragment is not protected and suffers from browsing by goats, possums, rabbits and wandering stock (Wilson, 1992a) (Figure 4.5).

Ngaio Point on the north western side of Akaroa Harbour (Wilson, 1992a; Wilson and Wright, 1995). Ngaio Point receives a greater level of rainfall and has slightly different soils to Quail Island but is very useful in forming a picture of the possible forest of Quail Island (Figure 4.6).

The Gore Bay Scenic Reserve is located south of Kaikoura between the Waiau and Hironui Rivers. It is a large stand of coastal broadleaf forest that covers 54.7 ha and ranges from sea-level to 100 m. Unlike Quail Island it has highly fertile limestone soils and an average rainfall of approximately 900 mm (Mason, 1969, Kelly, 1972). It is the only example of eastward facing coastal forest of any note in Canterbury available for interpolation for Quail Island (Figure 4.7).

The Ahuriri Bush is located on the shady south west flank of the Port Hills and lies between 40-200m asl. It lies beneath the 900mm and 1000mm isohyet (Figure 3.3). It covers about 63ha and is made up of predominantly second growth kanuka and mixed broadleaf forest with a lot of podocarp regeneration. (Connor, 1978; Wilson, 1992a) (Figure 4.8).



Figure 4.4 North West Bay near the head of Okains Bay



Figure 4.5 Tipparary located between Port Levy and Pigeon Bay



Figure 4.6 Ngaio Point on the north western side of Akaroa Harbour



Figure 4.7 Gore Bay south of Kaikoura



Figure 4.8 Low altitude forest edge at Ahuriri Valley Bush, showing small leaved shrub understorey beneath a kanuka canopy.

4.2.2 Reference State # 1: The Character of the Pre-settlement Forest Vegetation and Avifauna

Sheltered Southern Bays

1a) Rocky Faces. The woody vegetation on the most exposed rocky southern facing coastal island zone would have been dominated by coastal scrub. This would have been made up of coastal scrub and forest species relatively small in stature compared to their inland counterparts due to the effects of exposure to wind and salinity. Here the canopy would have been made up of ngaio, ahiraho, *Coprosma crassifolia*, manuka,

kanuka and *Hebe* sp? *Muehlenbeckia complexa* and flax, all of which are able to establish in the rock cracks with very little soil.

Bracken (*Pteridium aquilinum*) and Richard's shield fern (*Polysrichum richardii*) would be the principal ferns in this zone, with the leatherleaf fern (*Pyrossia serpens*) occupying the vertically flat rocky faces. Where the coast is not so steep and rocky, but where the coast slopes down to meet mudflats salt marsh ribbonwood (*Plagianthus divaricatus*) would have formed the dominant littoral vegetation along the with *Muehlenbeckia complexa* and an assortment of halophytic monocots such as glasswort, *Salicornia* etc. Saltmarsh ribbonwood (*Plagianthus divaricatus*) forms a dense cover providing a moister and salt protected environment for less salt and drought tolerant species such as the transitional Ti tree or cabbage tree (*Cordyline australis*). Through this dense foliage would emerge the most common forest species of mahoe (*Melicytus ramiflorus*).

Southern Coastal Forest.

1b) Where soil is able to develop, slightly less robust species could have established. Here one would expect a canopy of low coastal forest trees not unlike that of Gore Bay and Ngaio Point in Akaroa. Ngaio and ahiraho would been the most conspicuous trees, followed by tree tutu and broadleaf, cabbage tree, *Pittosporum tenuifolium*, akeake (*Dodonaea viscosa*), mahoe and possibly *Carpodetus serratus*. These are salt and drought tolerant and would have been concentrated in this near coastal region as well as being found over most of the island.

Southern coastal hillslopes

1c) Moving slightly further inland from the coast where the soils are deeper and their moisture holding capacity greater the larger drought tolerant species of the second forest tier of tall broadleaf species would have appeared. These could have included karamu (*Coprosma robusta*), karamu x *C. propinqua*, mahoe (*Melicytus ramiflorus*), tree tutu (*Coriaria arborea*), putaputaweta (*Carpodetus serratus*), five finger (*Pseudopanax arboreus*), fierce lancewood (*Pseudopanax ferox*), ngaio (*Myoporum laetum*), broadleaf

(*Griselinia littoralis*), cabbage tree (*Cordyline australis*), red mapou (*Myrsine australis*), lemonwood (*Pittosporum eugenoides*), ribbonwood (*Plagianthus regis*), titoki (*Alectryon excelsus*), kaikomako (*Pennantia corymbosa*), lacebark (*Hoheria angustifolia*), tree fuchsia (*Fuchsia excortica*) and kowhai (*Sophora microphila*). In sites of disturbance or canopy gaps, totara (*Podocarpus totara*) would emerge and eventually overtop these broadleaf species forming part of the emergent canopy.

The shrub layer or third tier could have been comprised of kawakawa (*Macropiper excelsum*), *Fuchsia perscandens*, rohutu (*Lophomyrtus obcordata*), koromiko (*Hebe salicifolia*), *Hebe strictissima*, *Coprosma crassifolia*, *C.rhaminoides*, *C.rotundifolia*, *C.virescens*, *C.propinqua*, *C.areolata*, *C.lucida*, niniao (*H.lanceolatum*), *Melicope simplex*, *Urtica ferox*, *U.incisor* and *Helichrysum glomerata*. It is possible that the silver tree fern (*Cyathea dealbata*) may have occurred in the wettest most sheltered areas of this southern coastal region.

The climbing plants could have been represented by both bush lawyer *Rubus schidelioides* and *R.squarrosus*, the native jasmine (*Parsonia heterophylla*), *P.capsularis*, *Tetrapathaea tetrandra*, *Calystegia tugurioum*, *Clematis afoliata*, *C.foetida*, *Ripogonum scandens*, *Meuhlenbeckia australis*, *M.complexa* and the native passion vine (*Passiflora tetrandra*).

As for the forest floor, the fern layer was probably dominated by *Polystrichum richardii* with *Asplenium richardii*, *A.hookerianum*, *A.flabellifolium* and bracken (*Pteridium aquilinum*) in the most exposed areas. Herbs may have been bush flax (*Astelia fragrans*), *Acaena juvenca*, *Arthropodium candium*, *Cardamine debilis*, *Lagenifera strangulata* and *Libertia ixiodes*. Grasses may have been represented by *Poa mathewsii*, with sedges such as *Uncinia leptostachya*, *Carex solandri* and *C.raoullii*.

The plateau

2a) This area may have constituted one of the few coastal podocarp broadleaf lowland forests on rolling ground on Banks Peninsula. This site would be dominated by species

able to establish in both the moist cool conditions of the southern aspects (ie east, south, west) and the warm dry conditions of the northern aspects (ie northwest, north, northeast). On the least sheltered drier plateau sites, ngaio, five finger, broadleaf and red matipo may have been present. There are several wet depressions and natural drainage channels that provide habitat diversity in this region. Forest in these sites would be a little more lush on the southwards sloping sites with a concentration of moisture loving species. The emergent canopy was probably a mix of relatively low stature lowland totara and matai. In these gully areas the subcanopy may have consisted of lacebark (*Hoheria angustifolia*), kaikomako (*Pennantia corymbosa*), ribbonwood (*Plagianthus regis*), wineberry (*Aristolelia serrata*), lemonwood (*Pittosporum eugenoides*), kohuhu (*P. tenuifolium*), cabbage tree and small leaved milk tree (*Streblus heterophyllus*),

The dry northern coastal slopes

3) On dry rocky exposed sites one would expect to find *Meuhlenbeckia complexa*, matagouri (*Discaria toumatou*), dwarf kowhai (*Sophora prostrata*) and the dwarf prickly heath (*Cyathodes fraseri*). The forest in this area would have been less dense than the southern side with a greater proportion of drought tolerant and light loving species. The vegetation could be described as a tall dry maritime shrub and small tree canopy, comprised chiefly of drought tolerant species such as kanuka, golden akeake (*Olearia paniculata*), akeake (*Dodonaea viscosa*), *Corokia cotoneaster*, *Helichrysum lanceolatum* and *Coprosma crassifolia*. The canopy in these areas would probably be made up of *Myrsine australis*, *Pittosporum tenuifolium*, *Sophora microphylla*, *Plagianthus regis* and *Hoheria populea*. The third tier would have been made up of filiramulate shrubs such as *Coprosma crassifolia*, *C. virescens*, *C. propinqua*, *Teucrium parvifolium*, shrubby mahoe (*Melicactus mircranthus*) with tree nettle (*Urtica ferox*). The moisture loving species would have been concentrated in the wet depressions and around drainage channels. In the southern facing recovery sites more or less drought intolerant hardwood species could be found. Here the forest would resemble more the southern slopes already described.

4) Northeastern cliffs

The cliff community may have included the following species: coastal ferns would have been found in the moist sites and probably represented by *Asplenium oblongifolium*, *A. obtusatum* and *Pyrossia serpens*. Grass and grass like plants would have been represented by silver tussock, *Microlaena stipoides*, the local endemic *Festuca Banks Peninsula* blue tussock, toetoe (*Cortaderia richardii*), possibly blue grass (*Elymus solandri*), holygrass (*Hierochloe redolens*), windgrass (*Lachnagrostis pilosa*), wood rush (*Luzula banksianiana*) and saltgrass (*Puccinellia stricta*). The herb community would have been comprised of iceplant (*Disphysma australis*), native celery (*Apium prostratum*), *Einadia allanii*, shore groundsel (*Senecio glaucophyllus*) rauhuia (*Linum monogynum*), sea spurrey (*Spergularia media*), club rush (*Isolepis nodosa*) and native iris (*Libertia ixiodes*). Other species of herb present would have been, the native spinach or kokihi (*Tetragonia trigyna*), the white sun orchid (*Thelymitra longifolia*) and the native ginger (*Gingidia montana*). Closest to the sea one would have found the salt resistant glasswort (*Salicornia australis*) and *Sarcocornia quinqueflora*.

4.2.2.1 Pre-settlement avifauna and reptiles

As no archaeological records of avifauna on Quail Island are available, the following lists of the antecedent extinct avi-fauna and reptiles of Quail Island are speculative. The likely composition of the avifauna has been deduced from possible habitat requirements and general distributions derived from the literature. The principal sources used were: Atkinson and Millener (1990), Falla *et al* (1979), Gill and Martinson (1991), Wilson (1992a) and Worthy (1993).

The antecedent composition of the herpetofauna of Banks Peninsula prior to the European colonial period is not recorded and any attempt to reconstruct it can only be guess work. For this reason a reconstruction of this fauna has been largely avoided. Nevertheless, in general it is thought that the decline of the reptile community followed that of the avifauna, with habitat loss and predation from introduced mammals being the

principal causes (Towns and Daugherty, 1994). The four species of reptile that have survived are clearly capable of co-existing with predators and in open country and bush fragments and they have been included in the reconstruction of vertebrate guilds. The following references were used: McCann (1955), Sharrell (1966), Moore (1987), Whitaker (1987), Pickard and Towns (1988), Towns and Daugherty (1994) and Gill and Whitaker (1996).

4.2.2.2 Coastal species

Coastal species that had become totally extinct by colonial times and could have been represented on, or in the vicinity of Quail Island were the Chatham Island sea eagle (*Haliaeetus australis*) and the Auckland Island merganser (*Mergus australis*) (cf Wilson, 1992a; McCulloch, 1987; Gill and Martinson, 1991). Species that were present and had breeding colonies on the island during the colonial and contemporary periods, but are no longer found there are the white flippered penguin (*Eudyptula albosignata*) (Lands and Survey, 1981) and muttonbird or titi (*Puffinus griseus*) (Swindells, pers com). It is possible that the shore plover (*Thinornis novaezealandiae*) and the fairy prion (*Pachyptila turtur*) may have frequented the island (cf Wilson, 1992a).

4.2.2.3 Forest community of Quail Island

The following is a list of pre-settlement faunal communities that probably inhabited and/or frequented Quail Island. It consists of eight feeding guilds based on Atkinson and Millener (1990).

4.2.2.4 Ground herbivore guild

The remains of three species of moa are recorded in Otiran loess deposits dating 28,000

ys BP in the Port Hills vicinity of Quail Island. They were *Pachyormis elephantopus*, *Euryapteryx geranoides* and *Emeus crassus* (Worthy, 1993). Forest vegetation at that epoch was confined to sheltered refugia and grass-shrubland was the dominant vegetation. The largest of the three *P. elephantopus* was morphologically the best adapted to browse this open vegetation and it was consequently the most abundant moa at this time. The smaller *Euryapteryx geranoides* and *Emeus crassus* were better adapted to feeding on less fibrous foods such as the fruit of forest trees and shrubs, and owing to the scarcity of forest these two were less common. As forest reasserted itself with the amelioration of the climate through the post glacial (Holocene period) to the beginning to the last Millennium, *Emeus crassus* and *Euryapteryx geranoides* probably became more abundant (Worthy, 1993). As sea-levels have not changed sufficiently over the last one thousand years in the Lyttelton region (Bob Kirk, pers com), it may have been possible for these birds to cross at low tide from the mainland to the island and *vice versa*. It would therefore not seem unreasonable that all three moas foraged on Quail Island.

4.2.2.5 Arboreal Herbivore

The red crowned parakeet (*Cyanoramphus novaezelandiae*) and yellow crowned parakeet (*C. auriceps*) comprise this group. Both feed mainly on leaves, shoots, flowers and seeds. The red-crowned variety favours the forest edge while the yellow crowned prefers the closed forest. See Atkinson and Millener (1990) for details.

4.2.2.6 Frugivore/herbivore

The kereru (*Hemiphaga novaezelandiae*), kokako (*Callaeas cineras*) and possibly the kakapo (*Strigops habroptilus*) would have been the principal members of this group. All are dependent on leaf matter for food, but successful breeding is dependent on fruit availability. Competition was avoided spatially by feeding at different levels in the

forest and temporally by staggered of the breeding seasons (Atkinson and Millener (1990). The kereru and kokako were probably both present on Quail Island during this time, although it is impossible to tell whether the flightless kakapo was also present.

4.2.2.7 Frugivore/insectivore

The kaka (*Nestor notabilis*) forages for fruit but is also dependent on insects not sought by other frugivorous species (Atkinson and Millener, 1990).

4.2.2.8 Nectarivore

Tui (*Prosthemadora novaeseelandiae*) and bellbird (*Anthornis melanura*) avoid resource competition by feeding on different flowers and selecting different food sources at different times of the year. Tuis are reliant on fruit during the winter while bellbirds are dependent on insects at this time. The kaka also can be included in this guild (Atkinson and Millener, 1990). The jewelled gecko (*Heteropholis gemmeus*), the forest gecko (*Hoplodactylus granularis*) and the spotted skink (*Oligosoma lineocellatum*) could also be included here.

4.2.2.9 Ground Insectivores

It is known that weka will feed on the mudflats and a weka was recorded having crossed from Governors Bay to Quail Island (Ward, 1850). It is possible that kiwi could have done the same. This guild may have consisted of the brown kiwi (*Apteryx australis*), spotted kiwi (*A. haastii*) weka (*Gallirallus australis*) and the robin (*Petroica australis*).

4.2.2.10 Smaller arboreal insectivores

This guild consists of nine species: brown creeper (*Mohua novaeseelandiae*), yellowhead (*Mohua ocrecephala*), rifleman (*Acanthisitta chloris*), bush wren (*Xenicus longipes*), shining cuckoo (*Chrysococcyx lucidus*), fernbird (*Bowdleria punctatus*), grey warbler (*Gerygone igata*), fantail (*Rhipidura fuliginosa*) and South Island tomtit (*Petroica macrocephala*). Competition would have been avoided by foraging in specific combination of feeding levels, feeding stations and mode of feeding and prey (Atkinson and Millener, 1990).

4.2.2.11 Larger arboreal insectivores

This guild probably consisted of eight species: long tailed cuckoo (*Eudynamis taitensis*), piopio (*Turnagra capensis*), saddleback (*Philesturnus carunculatus*), kingfisher (*Halcyon sancta*), New Zealand owlet nightjar (*Aegotheles novaezealandiae*), morepork (*Ninox novaezealandiae*), laughing owl (*Sceloglaux albifacies*) and kaka (*Nestor notabilis*). Competition would have been avoided through use of different forest strata and the selection of different prey (Atkinson and Millener, 1990).

4.2.2.12 Major predators of vertebrates

It is possible that the following species six frequented Quail Island in pre-settlement times although to what extent cannot be determined. New Zealand eagle (*Harpagornis moorei*), New Zealand falcon (*Falco novaeseelandiae*), Eylesi's harrier (*Circus eylesi*), Australasian harrier (*Circus approximans*), South Island adzebill (*Aptornis defosser*) and the New Zealand crow (*Palaeocorax moriorum*). Competition was avoided by different hunting techniques and size of prey taken (Atkinson and Millener, (1990).

4.2.3 Reference State #2: The character of the colonial old growth forests

The colonial forests are those observed and recorded by European explorers and colonists before the impact of settlement had taken effect. One of the best account of the character of the bird community in sub-humid maritime old growth forest, comes from a description written in 1838 of the Maori settlement at Puari in Port Levi. It was written by Dr. Felix Mayard, a ships surgeon of the French whaling vessel *Asia*. Mayard describes the forest as being comprised of many podocarps and descending almost to the waters edge. In the early morning in the forest margin he records the songs of the following nine species: bellbird, tui, saddleback, pio pio, kokako, yellowhead, kereru, brown creeper and kaka (Mayard and Dumas, 1937; Ogilvy, 1990 p.70).

The impact of the Polynesian resulted in a wave of animal extinctions. This was due principally to the loss of habitat, over hunting and the introduction of mammalian predators, the kiore (Polynesian rat) and the kure (Polynesian dog) (Bell, 1990; Holdaway, 1996). Approximately one third of the total forest area of Banks Peninsula was cleared during this period. Those species most affected were those large flightless species of value for food, those species dependent on them and species that could not adapt to mammal predation (Wilson, 1992a; Atkinson and Millener, 1990; Bell, 1990; Towns *et al*, 1990). Notable was the loss of the entire ground herbivore guild of moas, along with the giant eagle that may have been dependent on them for food. Furthermore the loss of the ground herbivore guild occurring some 500 years ago may have had a considerable impact on the ground flora and understorey. This would have resulted in composition and structural changes in vegetation (*cf* Caughley, 1989).

Of the major predators of vertebrates guild only the harrier and the N.Z. falcon remained. Further extinctions included the owl nightjar. It is not known how many plant or invertebrate species were lost although the figure is thought to be low (Wilson, 1992a).

4.2.4 Reference state # 3: The character of the contemporary mature post-colonial forest

These forests differ from the pre-colonial forests in that there has been a radical change in the composition and abundance of vertebrate species and an unknown number of invertebrate species. There has been a loss of numerous species and the addition of many others species, although losses outnumber gains (Bell,1990). All the remnants are forest fragments and all suffer from edge effects and mammalian browsing. Added to this is a suite of post-colonial species.

4.2.5 Reference state #4: The character of second growth forest **Pre-settlement second growth forest**

This type of forest occurs in response to some sort of disturbance event and its frequency would directly relate to the occurrence of fire, slips and wind throw etc. It can be divided into two types. Firstly, a kanuka dominated canopy that is found chiefly on the drier northern facing slopes. Secondly, in the moister southern aspects kanuka becomes scarce and the canopy is made up of an assortment of fuchsia, mahoe, five finger, lemonwood, lacebark, titoki, marble leaf, pigeon wood, kowhai, kaikomako and totara. In comparison to old growth forests, second growth forests are often more open, more illuminated, drier, with less litter and greater species richness.

In unprotected contemporary second growth forests understoreys are rare, but where protection can be afforded there is an array of bird and wind dispersed small leaved shrubs, trees and ferns (Wilson, 1992a). An examination of one such forest fragment may give an indication of the character of the pre-settlement second growth forest. For example in the protected northern lowland areas of the Ahuriri Valley Bush the understorey is made up of bird dispersed *Coprosma*s, often concentrated at the bases of adult kanukas, ribbonwoods and kowhais (Figure 4.8). Frequently observed were, *C.virescens*, *C.crassifolia*, *C.propinqua*, with some *C.rotundifolia*. Other shrubs present

were the bird dispersed *Melicope simplex* and the wind dispersed *Helichrysum aggregatum*). Also seedlings of forest canopy trees such as kowhai, ribbonwood and tree nettle (*Urtica ferox*). *Meulenbeckia complexa* and *M. australis* were present, often covering small seedlings or forming shrub like clumps. Ferns were chiefly the necklace fern, *Asplenium terrestre* and *Polystrichum richardii*.

In my opinion in the moister southern facing mixed broadleaf second growth forests, the composition of the avifauna would not be overly different from the old growth forests. Furthermore it is uncertain whether any of the species can be regarded as solely dependent on old growth forest. However it is more likely that certain species would be more frequent in old growth than second growth forest. For example in second growth forest there is usually a scarcity of litter, fallen logs and the fruit supplied by podocarps. With a scarcity of large fallen and standing dead trees invertebrate food resources and nest sites for hole nesting birds would be limited. In this way hole nesting species such as the yellowhead, karariki, saddleback and morepork may have been restricted to old growth forest at least for breeding purposes (cf Elliot, 1990 & Craig, 1994).

4.2.6 Reference state #5: Colonial second growth forests

It is not known whether there is any discernable difference between the vegetation of the pre-settlement second growth forests and the colonial forests. However it is likely that the effect of the loss of the ground herbivore guild may have had some effect on the species composition of lower forest layers (cf Caughley, 1989).

4.2.7 Reference state #6: Contemporary second growth forests

The conflagrations that occurred during European colonisation destroyed nearly all of the forest cover on Banks Peninsula. Tiny fragments of forests in southern facing

refugia was all that remained of the forest. Into the ashes were sown cocksfoot and other pastoral grasses for sheep farming. The intensity of farming was dependent on the success of overseas exports of sheep products. With the formation of the E.E.C in the late 1960s and the loss of Britain as a major market for these goods, along with the deregulation of the farming sector in the mid-1980s, it became uneconomic to maintain extensive areas of pasture (Willis and Kirby, 1985). The result was that the land with the least economic potential reverted to scrub and eventually to second growth forest. At present there is approximately 9000 ha of this type of forest. Kanuka forest constitutes about 3000 ha while mixed broadleaf forest makes up 6000 ha (Wilson, 1992a).

Contemporary second growth forest lacks palatable species such as 7 finger (*Schefflera digitata*), ground and tree ferns (Wilson, 1992) and very often any sort of understorey. In the low altitude southern areas of the Ahuriri Valley Bush, the canopy is made up of titoki, fuchsia, ngaio, marbleleaf, along with regenerating podocarps such as halls totara and matai. The understorey is made up of thick leaf litter, with much *Urtica ferox*, *Coprosma virescens*, matagouri and kanuka in well lit sites as well as seedlings of kawakawa, *Myrsine australis* and ngaio.

The contemporary second growth forests are strongholds for the remaining avian pre-colonial species unable to adapt to the pastoral and/or scrubland habitats. These include tomtit, brown creeper and rifleman and to a lesser extent the bellbird and kereru. They also harbour a range of post colonial species such as the blackbird, song thrush, starling and silvereye (Wilson, 1992a; Crossland, 1996; pers obs).

4.2.8 Reference state #7: Character of small leaved shrubland and treeland

Pre-settlement scrub

This vegetation is a precursor to second growth forest and develops after disturbance. In pre-settlement times when forest was dominant on Banks Peninsula, small leaved

shrubland occupied the forest edge, dry bluffs, and very exposed sites. The general species assemblage was likely to have been comprised of the following: matagouri, kanuka, manuka, *Corokia cotoneaster*, *Helichrysum lanceolatum*, *Coprosma crassifolia*, *C. propinqua*, *C. oblongifolium*, *Melicope simplex*, *Myrsine divaricata*, with creepers *Meuhlenbeckia complexa* and *M. australis*. These shrubs would be surrounded in a matrix of silver tussock and bracken.

Bird species that frequented these sites in pre-settlement times but did not survive to the colonial period were the three species of moa, the adzebill, the native crow and the New Zealand eagle, Eyles harrier may have hunted over these sites. (cf Gill and Martinson, 1991). Those species present in the pre-settlement and colonial period were the takahe, kakapo, New Zealand quail, fernbird, red crowned kakriki, piopio, saddleback, weka, robin. The laughing owl may have ventured into this zone through hunting at the forest edge. Those species found in pre-settlement times to the contemporary period were bellbird, fantail, grey warbler, kingfisher, long tailed cuckoo and shining cuckoo.

4.2.9 Reference state #8: Colonial shrubland and treeland

The divaricating habit of the small leaved shrubs is thought to be an adaptation to a combination of browsing pressure from moas and to climatic extremes (McGlone and Webb, 1981). Moas had been extinct for approximately 200 years before the introduction of mammals in the colonial period. During this period no changes in the vegetation has been noted. As with the above examples of second growth and old growth the effect of the loss of this guild and other extinction is not known.

4.2.10 Reference state #9: Contemporary shrubland and treeland

The recolonisation of formerly forested land adjacent forest fragments on Banks

Peninsula occurs in four ways depending on the kind and level of browsing pressure.

i) Small leaved shrubland develops in the presence of stock and low levels of pests. These shrubs must be both resistant to browsing from goats, rabbits, wallabies as well as farm stock. This vegetation can be divided into two categories depending on aspect. On the southern aspects matagouri, bracken, manuka, kanuka, *Coprosma crassifolia* and cabbage tree make up most of the woody cover. Outside southern faces a kanuka grassland complex develops and spreads outwards when occasions of low browsing pressure permit it.

ii) The second category is treeland. Unpalatable forest trees are able to establish in pasture in the presence of stock. Grazing animals allow colonisation of certain forest trees by suppressing pasture grasses that exclude tree seedlings. treeland consists usually of kanuka, ribbonwood, lacebark, kaikomako, totara, kowhai and pepperwood.

iii) Thirdly abandoned farm and pastureland that is browsed by only wild herbivores. This is the case for unprotected peripheries of second and old growth forest remnants. In these sites pests at very high number have a more destructive influence than stock. In most instances the ground will be invaded by gorse and broom as described in Chapter Three. In the absence of these post-colonial colonisers small leaved shrubs such as *Corokia cotoneaster*, *Coprosma virescens*, *Myrsine divaricatus*, mahoe, *Discaria toumatou*, are able to get a foot hold.

iv) The fourth category is the colonisation of sites by palatable shrub and tree species out of reach of pests and stock. colonisers may include *Hebe salicifolia*, *Alectryon excelsum*, *Griselinia littoralis*, *G. lucida*, karaka, kawakawa

This vegetation partly plays host to variety of imported and self introduced species as well as a few pre-colonial species; these have already been described in Chapter Three.

Birdlife in scrubland and grassland

Species that were most adapted to this vegetation were partly herbivorous species such as such as the moas, takahe and kakapo and also the red crowned parakeet. Other species would have included the small insectivorous species such as fernbird, pipit and New Zealand quail. In colonial times the moas had disappeared but the others remained but went into rapid decline after habitat modification. The contemporary pre-colonial avifauna now consists only of the pipit and harrier with a large number of newly imported species from Europe making up the granivorous and worm eating guild.

Extant pre-colonial avifauna and reptiles that used to inhabit the shrubland, second growth and old growth forests of the subhumid maritime bioclimatic zone and possibly Quail Island are presented Table 4.1 below. It is from this list that species for translocation to the island will be drawn. Those species that were considered appropriate for translocation to Quail Island are discussed in detail in Chapter 8.

Reptiles that prefer the forest edge and disturbance sites may have profitted from bush clearance. *Haplodactylus maculatus* is suited to the Quail Island habitat although it is not known why they do not occur there now.

4.2.11 Possible changes in the Quail Island avifauna

With the destruction of almost all of the remaining forest on Banks Peninsula during the colonial period, there was naturally a loss of all the forest bird specialists. Twenty-two out of twenty-nine forest bird species were lost between pre-colonial and colonial periods (Wilson, 1992a). With the near complete clearance of woody vegetation from Quail Island there was the loss of many shrubland species species such as; tomtit, rifleman, brown creeper and kereru. This brings the total possible losses to thirty out of thirty-seven and nineteen gains through species introductions (five species of mammals and fourteenspecies of birds); losses out number gains two to one.

Dramatic losses occurred in the following guilds. The major vertebrate carnivores lost all but one avian member, the harrier. However this guild gained at least three species of mammal from Europe, all of which are present on Quail Island and able to inhabit forest. The smaller vertebrate predators suffered major losses, losing seven out of the eight species. This guild is now made up of kingfisher, with the little owl along with the white backed magpie, the hedgehog and the ship rat. Of the small arboreal insectivores only the fantail and the greywarbler remain on the island. It is possible that the shining cuckoo makes visits to the island although it has not been recorded there. This constitutes a loss of six species. The ground insectivores suffered a loss of five species retaining the pipit and receiving the hedgesparrow from Europe. The tui and the kaka were lost from the nectarivore guild after forest clearance leaving only the bellbird until the self introduction of the silvereye and the introduction of the starling which although not at all a honeyeater feeds occasionally on nectar. The frugivore/herbivore guild has disappeared from the island. The kereru frequents bush fragments and gardens in the vicinity of Quail Island but is not recorded on the island itself. The arboreal herbivore guild consisting of the two parakeets or kakarikis disappeared completely. The ground herbivore guild saw the loss of all three possible moa species and the New Zealand quail. This guild is now comprised of two post-colonial, species the rabbit and the California quail. With the advent of Europeans with pastoralism and amenity vegetation and the acclimatization of a variety of species introduced for largely sentimental reasons three new guilds were created: the Granivorous-Insectivorous, Frugivorous-insectivorous-granivorous and Ground frugivorous insectivores.

Those pre-colonial avian species that remained were generalists, equally at home in open country, forest edge, forest disturbance sites as well as the forest interior (e.g. kingfisher, fantail and greywarbler). In many instances there was an expansion of their range, obvious examples are the pipit and the harrier. The array of species introduced from Europe were to complete the English pastoral replica. With a complement of European plants these species were well suited to the pastoral landscape. The remaining pre-colonials merged relatively well with these new arrivals.

4.3 Chapter Summary and Conclusions

It is likely that Quail Island was forested in pre-settlement times. It has been proposed in this chapter that the forest vegetation that probably existed on the island was cleared for agricultural and strategic purposes by early Polynesian settlers, such as the Ngati Mamoe.

The antecedent forest vegetation of Quail Island was deduced by using a range of methods in an eclectic manner. The chief method employed was the interpolation from the landscape-vegetation relationships. Forest fragments in areas environmentally analogous to Quail Island were sought by matching the New Zealand Land Resource Inventory (N.Z.L.R.I) code and the Land Use Code (L.U.C) for Quail Island to the codes of sites that support and used to support forest.

The most significant extant sites of forest were the old growth forest fragment of North West Bay near Okains Bay, Tipparary between Port Levy and Pigeon Bay and Ngaio Point in Akaroa Harbour. These sites are not afforded any formal protection and they are browsed by introduced mammals. This means that they lack the palatable forest understorey plants. To depict an image of what the forests may have looked like, the Protected Natural Area (P.N.A.) of the Ahuriri Valley Bush in the Port Hills Ecological District was examined. Those species known to be confined to the montane or lowland bioclimatic zone and to either the Akaroa or Port Hills Ecological Districts were not included in the forest descriptions and species lists.

In order to build up lists of ecologically appropriate species for translocation and compilation of species pools, descriptions of old growth, second growth scrub and treeland from the pre-settlement, colonial and contemporary periods were given. These have been termed restoration reference states. As there have been little or no extinctions of plants since the advent of humans the pre-settlement vegetation reference state is considered the most important guide.

The likely pre-settlement vegetation of Quail Island could be divided into southern and northern forest types. The wetter southern areas could have supported a greater concentration of less drought resistant species compared to the drier northern aspects. The supposed antecedent vegetation was described by running an imaginary transect from the southern most tip of the western arm of South West Bay (L/U#9) to the northern most tip of North West Slopes (L/U#7). Included is a description of the possible non-forest vegetation of the north east cliffs (L/U#5).

Owing to the close proximity of Quail Island to the mainland the pre-settlement forest avian community of Quail Island was probably not unlike that of the rest of the maritime forest zone of Banks Peninsula. Resident populations of forest birds would be limited by territory sizes and resource allocation. When populations exceed the island's carrying capacity emigration to the mainland or local extinction would have occurred.

The island possibly constituted the lowland part of an internal migration from the upland areas in the winter to escape the cold and take advantage of early flowerings and late fruiting vegetation. It is considered that the open water or mudflats would not have posed a significant psychological or distance barrier for all of the volant species present on the Banks Peninsula, and the majority of these species were probably present on the island. As flightless species such as the weka, farm stock and people are capable of crossing the mudflats, it is assumed that most of the flightless species were present, notably the three species of moas. It is uncertain whether the kakapo, kiwi or stout legged wren would have frequented the island.

However the avian community may have been made up of up to nine feeding guilds: the ground herbivore, arboreal herbivore, frugivore/herbivore, frugivore insectivore, nectivore, ground insectivore, small arboreal insectivores, large arboreal insectivores and major predators. The island may have supported a variety of now totally extinct coastal species such as Auckland island merganser and the Chatham Island sea eagle. It is known that until recently Quail Island supported breeding colonies of muttonbird (titi) and white flippered penguins.

With the advent of the Polynesian and European, Banks Peninsula was almost entirely stripped of its forests, resulting in two great waves of species extinctions. What remains is a range of unspecialised pre-colonial species that are able to move between scrub, grassland, second growth and old growth forest fragments. These have combined with the array of introduced English pastoral and woodland species well adapted to this sort of open country. It is likely that most of the post-colonial avian species (especially those reliant on post-colonial vegetation, such as the granivore) will be marginalised with the restoration of a predominantly pre-colonial old growth forest.

In conclusion, the collation of reference states has achieved the following. Firstly they provide a list of ecologically appropriate species for each vegetational change stage or meta-stable state of forest recovery. Secondly they reveal that if the pre-colonial model for each stage is achieved it is likely that some resources will go unexploited. This allows for future evolutionary radiation and opportunities for colonisation from offshore notably from Australia. By examining the nature of these gaps and matching these to possible foreign species, predictions of the future avifauna may be predicted.

Table 4.1 Extant pre-colonial avifauna that used to inhabit the shrubland, second growth and old growth forests of the subhumid maritime bioclimatic zone and possibly Quail Island

Species	Scrub and Shrubland	Second growth forest	Old growth forest
New Zealand Falcon	*	*	*
Morepork	-	*	*
Brown creeper	-	*	*
Yellowhead	-	?	*
Brown creeper	-	*	*
Rifleman	-	*	*
Fernbird	*	-	-
South Island tomtit	-	*	*
South Island robin	-	*	*
Great spotted kiwi	-	*	*
Tui	-	*	*
Kaka	-	*	*
Kokako	-	-	*
Red crowned kakariki	*	*	*
Kereru	-	*	*
Jewelled gecko	-	*	*
Common gecko	-	*	*
Spotted skink	-	*	*
<i>Haplodactylus maculatus</i>	*	-	-

Chapter 5:

Social Impact Assessment Scoping Exercise

5.0 Introduction

In the chapters 1 and 2, I chose a definition of ecological restoration and developed a restoration philosophy and goal for Quail Island. In the Chapters 3 and 4, I established the contemporary, colonial and pre-settlement reference states for the proposed ecological restoration of Quail Island. In this chapter I attempt to put the Quail Island restoration proposal into its social and cultural context.

It has been argued that it is largely counterproductive to try and exclude people from conservation projects (Craig, 1990, 1994; see Chapters 2 & 6). If Quail Island is to be restored, it is important that the concerns of the community be taken into account. In this chapter I identify the principal stakeholders and their main concerns. These factors will be used in the development of prescriptions for the role of the community in the restoration concept plan (Chapter 6). Those factors that are perceived as inhibiting the restoration proposal are discussed in Chapter 7.

5.1 Scoping Methodology

The Social Impact Assessment (SIA) scoping process, as described by Taylor *et al.*(1995) provides a methodology to identify the concerns and issues of those community groups most likely to be affected by the proposed restoration project. However the first task was to identify the principal stakeholders. This was done through an examination of secondary sources. Firstly literature produced by current open access island and mainland habitat island restoration projects in New Zealand were studied. The following references were used: Atkinson,1990, Craig,1990, Miskelly,1995, Mitchell *et al.*,1994, Fuller,1994, Department of Conservation,1996. Furthermore

those individuals that have close contact with the running and management of Quail Island were consulted. These consisted of staff of DoC the Christchurch Field Centre, John Watson, Ross Corbett and Stuart Moore, as well as the manager of the Quail Island ferry service, Lyttelton Harbour Cruises, Brian Shankland.

The following community groups are considered to be the principal stakeholders: recreational users of Quail Island, the Department of Conservation managers of the island, ferry service to Quail Island - Manager of Lyttelton Harbour Cruises, Forest and Bird Protection Society, residents of the Lyttelton Harbour Basin and the *Tangata Whenua*. In order to get a full range of concerns representatives of the Banks Peninsula District Council Planning Section, the Banks Peninsula Federated Farmers and The Historic Places Trust were also consulted. It was then the task to identify through public consultation their major concerns and the major issues surrounding the proposed project. In the following section I present the results of the consultation process.

5.2.0 Visitor perceptions of Quail Island and support for the Restoration Concept.

5.2.1 Background information

One of the most significant stakeholder group in the Quail Island restoration project is the recreational users of the island. The island is appealing because of its close proximity to Christchurch, apparent isolation, uncrowded beaches which are sheltered from the cool summer easterly wind. The principal activities are picnicking, swimming, boating, waterskiing and short walks (Department of Lands and Survey, 1982; Ross Corbett, pers com). It is notable that comparatively few people use the Walkway itself, preferring instead the beaches. It was established in a survey conducted by the Department of Conservation that an estimated 33,000 people used the island over the 1993/94 summer period from December to February. It was not determined what proportion arrive by ferry (Ross Corbett, pers com). In response to this I interviewed Mr. Brian Shankland, the manager of Lyttelton Harbour Cruises. He estimated he

carried between 100-150 people per day during this summer period, most of them school children. That is between 9900-10,350 visitors reached the island by ferry over that summer period. Put another way approximately 23-24% used the ferry service to get to the island during this period. Numbers during the off season are considerably lower; a regular service is not run and access by ferry is through charter only.

The island's reserve infrastructure is well developed and maintained. There is now a domestic fresh water supply on the island that supplies the DoC workers' accommodation and maintenance buildings. There is also a sophisticated toilet system at Swimmers Beach that was installed at some expense. There is electricity and a communication system on the island. Wastes are disposed of using sumps and pit toilets. Visitors are encouraged to take their garbage with them as no bins are provided (Stuart Moore and Ross Corbett, pers comm).

5.2.2 Visitor Survey

Aims

The main purpose of the questionnaire was to highlight potential concerns and issues of recreational users, as well as give an indication of support for the concept.

Methods

Forty visitors were sampled on the two popular beaches of Quail Island over the Labour Day holiday period, 1996. A series of open ended questions were asked. The principal questions asked were: whether they supported the concept of ecologically restoring the island and why, followed by whether they would appreciate the island more/less/same as before if it was restored and why. They were then asked what they liked and disliked about Quail Island.

Results

The most significant concerns and issues considered relevant to the development of the restoration concept are summarised below. The full survey results and a sample questionnaire are presented in Appendix 5a. What the visitors liked most about the island is its sense of tranquility.

The greatest dislike was the shattering of the tranquility by power boats. An associated concern is that the island retain its uncommercial and undeveloped nature. Further, most visitors said they would support the restoration concept if it allowed them continued use of the beaches and picnic area, highlighting that it should not inconvenience them or drive them away. Most visitors said they would give a small donation of money (\$1-\$2), time and labour to plant trees. Although some disliked the island's barrenness and the presence of exotic trees, many appreciated the island the way it was. It was sometimes stipulated that respondents would support the concept if the exotic trees were not destroyed indiscriminantly. Occasionally concerns were raised over whether Quail Island did or could support forest. If it could not, then the restoration would be perceived as unnatural and likely to fail. Owing to the doubt some people had, it was a concern that the project needed to be well thought out and well managed.

Discussion

The visitor scoping survey showed that the majority of those interviewed supported the idea of ecologically restoring Quail Island. Furthermore they would appreciate it more and visit it more often if the island's forests were restored. These results may reflect a general trend towards a willingness to participate in conservation projects as indicated by Craig, 1990.

Questions were structured in such a way to be unbiased. However on hindsight it may have been better to have asked whether the respondent supported the restoration concept after asking what they liked and disliked about the island. As knowing what the purpose of the questioning may have led them to say what the interviewer wanted to hear. It would have been less biased approach to have reversed the order of the questions. This problem could have been avoided by conducting a pilot test survey which would have identified this flaw in the questionnaire

5.3 Principal issues and concerns raised by the Department of Conservation

The reserve's ranger Mr. John Watson, the DoC Christchurch Field Centre Manager Mr. Mr. Stuart Moore and Mr. Richard Suggart were consulted. During this time their concerns and opinions regarding the proposal to restore Quail Island were obtained. Their main views are expressed below.

In 1982 a revegetation programme was undertaken on Quail Island. Due to high seedling mortality caused by a combination of rabbit browsing, the summer drought and salt spray it was abandoned soon after. It is believed that owing to the failure of this project that Quail Island does not presently have a forest environment. Furthermore it is considered unlikely that the island supported forest in pre-settlement times. Restoration of forest on the island is therefore considered "unnatural" and destined to fail. It is also believed that the rabbit population is "open" and that serious control programmes will always be ineffectual owing to the risk of reinvasion from the mainland. It is believed that revegetation is consequently a very difficult if not impossible task. There is opposition to the initiation of new and potentially expensive projects that would be a drain on already scarce resources; resources that could be better used in the management of existing reserves.

The adoption of a restoration strategy in which gorse and broom are allowed to spread naturally over the island to form a nurse canopy for native broadleaf colonisers, raises

some problems. Firstly gorse is an aggressive pastoral weed and the DoC is obliged by legislation to control it. They are also obliged under the Recreation Reserves Act to keep areas clear for recreation.

These concerns are not held by all in the department. Richard Suggart the administrative head of the DoC view the project favourably and does not regard the problems cited above as insurmountable. However Mr. Suggart is in favour of investigating the concept more fully. To this end the the concept of a community based restoration project for Quail Island was put into the DoC Canterbury Conservation Management Strategy Draft 1996 (Department of Conservation, 1996a&b).

5.4 Principal issues and concerns raised by the Royal Forest and Bird Society members.

To scope the potential principal concerns of the Royal forest and Bird Society and to scope whether they would be in support of the restoration concept. In September 1995 I presented the restoration concept as it stood at that time before the Canterbury Branch Committee of the Royal Forest and Bird Society for comment.

The results of the discussion showed that Forest and Bird members support and work closely with the DoC and share many of the same views expressed above. For example members of the committee saw the restoration of Quail Island as luxury and a potential drain on scarce resources. Notable additional concerns raised were regarding the possible effects of a Ngai Tahu claim over Quail Island and the future of a restoration project if such a claim was successful.

5.5.0 Principal issues and concerns raised by *Te Runanga O Rapaki*

The following information is derived from an interview with Mrs. June Swindells Secretary of the Rapaki *runanga* and the written submission (referred to as

Swindells,1996) on the Canterbury Management Strategy 1996, regarding the Community Participation in the Ecological Restoration of Quail Island (Department of Conservation, 1996b).

Before beginning this synopsis it is important to posit the concerns in the context of the Treaty of Waitangi and the history of the Crown's acquisition of the island. Quail Island remains of great cultural and spiritual significance to the Ngai Tahu of Rapaki. The validity of sale of the island in 1849 along with the rest of Whakaraupo (Lyttelton Harbour formerly known as Port Cooper) has always been disputed. The Waitangi Tribunal established that the entire Port Cooper area was appropriated in a dishonourable and illegal fashion. As a result the Tangata Whenua was rendered virtually landless. The tribunal recommended that *"..a clear duty now rests on the Crown to repair the grave harm done to the Ngai Tahu by the serious and numerous breaches of the Treaty and its principles."* It goes on to say that failure to redress past breaches is, in itself, a violation of the Treaty (New Zealand Waitangi Tribunal, 1991 p.99). The Department of Conservation under the Conservation Act 1987 must *"...give effect to the principles of the Treaty..."* (This also applies to the Reserves Act and Wildlife Act). Those principles of interest here are relate specifically to redress and partnership, both of which are discussed below.

5.5.1 Redress

The members of the *runanga* of Rapaki are seeking redress for Article II breaches of the Treaty of Waitangi. This includes the restoration of and continued access to cultural materials, such as *taonga* and *mahinga kai* which the Crown has failed to protect . They are aware that bird life in the area has steadily declined and they desire to see the return of native birds and other wildlife to their *rohe* (Swindells, 1996). Redress should involve the planting of native trees, cultural plants and the restoration of traditional animal populations for future use. Ideally populations of these organisms should be sufficient to allow the cultural harvest of these species to ensure provisions for future

generations.

Rapaki is not, however, seeking Quail Island directly for these purposes, instead they are looking for land that is both visible to them from their houses and located within walking distance. The *runanga* proposed the Lyttelton reserve as the most suitable to meet these purposes. The *runanga* is also interested in broadening their economic base through various ventures (Swindells,1996). I believe Quail Island has a number of ecotourism possibilities (Chapter 6).

5.5.2 Partnership

According to Chief Judge Durie the main Treaty principle to be given effect to, is one of mutual co-operation and trust or partnership between the Crown and Maori (DoC,1996). The Department of Conservation under the Conservation Act (1987) is required to form such a relationship with local *iwi*. *Te Runanga O Rapaki* has expressed a desire to enter into a partnership with both the community and the Department of Conservation through a project to ecologically restore Quail Island (Swindells,1996) .

The *runanga* supports the Quail Island restoration concept for a number of reasons. Firstly to see the island's natural wildlife and botanical environment enhanced. This they urge will do much to support the historical and cultural links with the island. Secondly the *runanga* desires to play an active role in the management of land within its *rohe* and the Quail Island project is a good opportunity to forge co-operative links between the current land managers and themselves. Thirdly, and most importantly restoring forest to the island is seen as an act of giving something back to the land which is a major concern for this *runanga* (Swindells, pers com) .

5.5.3 *Wahi tapu* sites

Restoration plantings can disturb archaeological sites through the digging of holes and root penetration (Miskelly,1995). It is essential to have a clear statement of the status of the *wahi tapu* sites for the managing body. Damage or destruction of any *wahi tapu* or archaeological sites can result in severe fines under the Resource Management Act (1991).

There are a number of undisclosed archaeological sites on the island held in silent files by the Department of Conservation. In order to write a comprehensive management plan it is important to know their location to ensure they are not disturbed. The historic sites may or may not be registered with the historic places trust. Registration will ensure their protection but also inform members of the public of their existence. In the past this has led to desecration of sites and the *runanga* is reluctant to release such information.

5.5.4 *Mana Whenua*

The *Tangata Whenua* under the Resource Management Act (RMA)(1991) retain *Mana Whenua* over their ancestral lands, which includes Quail Island. It is also important that the ancestral links with Quail Island are re-established and maintained. This is considered a matter of national importance under the Resource Management Act (1991).

5.6 Principal issues and concerns raised by chairperson of the Banks Peninsula Branch of Federated Farmers.

Ms. Pam Richardson, Chairperson of the The Banks Peninsula Branch of Federated Farmers, was consulted in a telephone interview. She was asked to give her opinion and what she thought the opinion of her fellow members would be of the proposal to restore

Quail Island. She did not think that farmers in the vicinity of Quail Island would object to the revegetation of land already gazetted as a reserve. There may be concerns however if gorse and broom is allowed to spread on the island unchecked, as would be the case under an MIM strategy. There are fears that this may lead to re-infestation of mainland farm areas. Concern would be raised if it could be shown that rabbits emigrate from Quail Island to the mainland re-infesting pasture.

5.7 Principal issues and concerns of the Canterbury Historic Places Trust

The island has a large number of European Historic Sites all of which are recorded and equipped with information plaques. Some of the sites are in a state of disrepair and there are plans to restore them. was consulted in a telephone interview. She was asked to give her opinion and what she thought the opinion of her fellow members would be of the proposal to restore Quail Island. The Historic Places Trust does not consider restoration of the island a threat to historic sites if care is taken to preserve both archaeological and historic sites and artifacts.

5.8 Principal issues and concerns raised by representatives of Lyttelton Harbour Residents Committee

Mrs. F.T.Thompson and Mr. V.McClimont of the Charteris Bay residents association and the Lyttelton Residents Association respectively, were consulted in telephone interviews. In both cases they could see no reason why residents would object to the proposal and that it was considered to be a good idea. Concern however was expressed that the existing exotic trees should not be felled indiscriminately leaving a "scorched earth effect".

5.9 Principal issues and concerns raised by John Christensen of the Banks Peninsula District Council.

Mr. John Christensen was consulted in a telephone interview. He considers that opinions of residents would be divided. Some may believe the island would be enhanced by restoration, while others may think it may in some way obscure the shape of this prominent landform.

5.10 Manager of Lyttelton Harbour Cruises

The manager of Lyttelton Harbour Cruises, Mr. Brian Shankland was consulted in a telephone interview. He was asked to give his opinion of the restoration proposal. Mr. Shankland would support any initiative on Quail Island that increased patronage of the ferry service.

5.11 Conclusions

With the exception of the DoC managerial staff of the Quail Island reserve, most of the stakeholders in the proposed project support or have no objection to the concept of restoring Quail Island with certain provisos. DoC managerial staff do not believe that Quail Island could support native forest and restoration is ecologically inappropriate as well as an unnecessary drain on scarce resources. However opinions within DoC are divided and the restoration concept was floated in the draft Canterbury Conservation Management Strategy. The main concern of visitors is that their use of the popular beaches should not be interfered with. *Te Rapaki O Runanga* has a significant interest as the island has cultural and spiritual significance to them. Partnership in management of Quail Island with the DoC would be viewed as redress of one of the breaches of the Treaty of Waitangi. Residents and visitors would be concerned if restoration resulted

in the clearance of exotic trees that have considerable amenity value. It is expected that some residents would be concerned that revegetation will alter the appearance of the island as a prominent landform.

Chapter 6:

The development of prescriptions for community involvement

6.0 Introduction

In the previous chapter I identified the concerns and issues of the principal stakeholders in the proposed Quail Island restoration project. In order to develop possible prescriptions for effective community involvement, it is necessary to reconcile these concerns with the restoration goal (Chapter 2.5). In this chapter I argue that the best way to do this is through an ecotourism paradigm within the framework of a Biosphere Reserve. This chapter opens with a discussion of the role of the public and tourists in conservation and restoration. In the following section I argue that "participative recreation" (James,1990) in restoration projects can often be classed as "ecotourism". This is followed by an elaboration of the definition of ecotourism used here and the role it can play in conservation and sustainable development. I also discuss some of the inherent problems associated with ecotourism in an "expansive growth economy". In the next section I examine two case studies of successful restoration projects of Tiritiri Matangi Island in the Hauraki Gulf and the Hinewai Reserve on Banks Peninsula which both engage participative recreation to subsidise their projects. I draw out the successful elements and use them to develop guidelines for community involvement in the restoration of Quail Island.

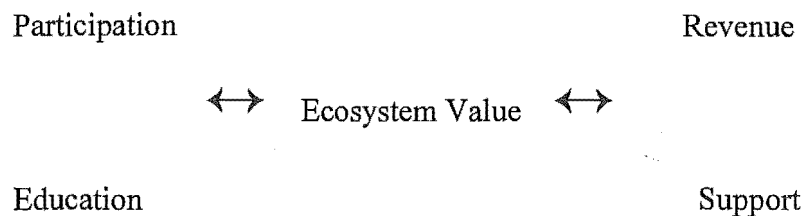
6.1 The public involvement in NewZealand conservation projects

In New Zealand the promotion of recreation on conservation estate is considered the most powerful advocacy tool available to conservation managers (Booth,1990). Further

it is widely accepted that conservation can better meet its goals through the inclusion of the public, and particularly indigenous peoples, than through their exclusion (Delvin and O'Conner, 1988; Dingwall and Simpson, 1988; Boo,1990; O'Connor and Simmon,1990; Bellingham,1990; Colvin,1991; Whelan,1991; Valentine,1994; Burns 1992; Craig, 1990, 1994).

In New Zealand the governing status quo has often regarded conservation as secondary to economic growth (O'Conner *et al*,1990; Peet,1993). For this reason there is often insufficient government funding for the DoC to achieve all that it would like. Conservation efforts are therefore prioritised to focus on saving what is representative, rare and threatened. The restoration of large areas of habitat such as Quail Island and Tiritiri Matangi Island is largely beyond the budget and priorities of the DoC. This means they are sometimes obliged to rely largely on non government organisations. In island restoration projects, public involvement is the norm and found at all levels, for example in supporting government officials and government initiatives, lobbying politicians,fundraising, management, initiation and implementation (Bellingham, 1990; Galbraith, 1990).

The symbiotic relationship between public participation and conservation is summarised by Craig (1990). In this paradigm there are mutual benefits for the public and the ecosystem. As ecosystem value increases so does the level of participation, education which lead to increased revenue and support.



In western countries there is heightened environmental awareness, along with a desire to be involved in conservation activities (Craig,1990; Miller *et al*,1994) and to view native species in natural surroundings (Robinson,1989; Nature Conservation Council(NCC),1981). The reasons given by volunteers for their involvement in such projects as the Tiritiri Island restoration were primarily concern for the global and local environment (James, 1990). Such reasons are utilitarian and they are often founded in conservation rhetoric (*cf* Miller, 1994 cited in King and Stewart, 1996). Nevertheless the advocacy of utilitarian arguments for conservation have proved to be most effective means to win support for conservation (Booth,1990).

In placing emphasis on public participation education and advocacy through visitation of the conservation estate the New Zealand Conservation Act (1987) has acknowledged these relationships. However in practice there is not a warm relation between the Department of Conservation and the public and volunteers (Craig, 1990; Bellingham, 1990). This is because the public are seen as the aggressors and the consumers of nature (NCC, 1981).

6.2 The Links between Conservation and Tourism

The expected growth of the tourism sector provides a more pressing problem facing the Department of Conservation. The majority of international tourists visit New Zealand for its national parks and its perceived "clean green image". Through a concerted promotions plan by the New Zealand Tourism Board (NZTB), visitor numbers to New Zealand are hoped to reach 3 million per annum by the turn of the century.

If profits are correctly distributed there is the potential for significant resources to be earned for protection and the possible expansion of conservation estate. However if this does not occur or does not go hand in hand with a modification of management regimes and infrastructure, it is inevitable that visitor carrying capacities will be exceeded

(NZTB,1993). If the natural and original carrying capacities are not secured then there will be a degradation of the very resource on which the industry is basing itself; in the tourism literature this is known as the "classic impasse" (Cater,1993).

There is a vital link between the tourism industry and environmental quality (Butler,1991; Valentine,1993; Buckley,1994; Pearce,1994), and it is in the industry's best interests to ensure the resources on which tourism is based are protected (Bornet,1992; Buckley,1994). Conservation management must find that delicate balance between securing the survival and well being of its resources and maximising visitor satisfaction (Valentine,1993). The relationship between the conservation estate and the tourist industry was acknowledged by the New Zealand Tourism Board (NZTB,1993). Ecotourism is often cited as one means the tourist industry is taking to protect both the cultural and natural environment (Buckley,1994; Goodwin,1996).

6.3 Towards a definition of ecotourism

Ecotourism is a term that is frequently used but remains largely ill-defined (Bottrill,1993; Goodwin,1996). It is the purpose of this section to select a clear definition. To begin what is tourism. Tourism requires travel from and origin to a destination and involves a minimum of one bednight (Pearce,1993). According to this definition whenever any local visits a place for the purposes of recreation and travel and stays the night they can be categorised as tourists engaging in the activity of tourism.

It has been proposed that tourism becomes ecotourism if it results in sustainable development and environmental conservation (Bottrill,1993; Valentine,1993; Buckley,1994; Goodwin,1996). For example Bottrill (1993) argues that the expression of ecotourism is environmental conservation and sustainable development. This results from the interplay of three key elements: The operational perspective (i.e.

environmentally sensitive management), the participant perspective (ie the tourist's level of motivation for an alternative tourist experience) and finally the Administration Perspective (i.e. involving planning operations that take into account the necessary environmental protection). Buckley (1994) states that only tourism that is nature-based, sustainably managed, environmentally educative and conservation supporting, can be described as ecotourism. Thus visits by volunteers or non-participatory tourists to ecological restoration projects involving one bed night can be categorised as tourism. Where this form of tourism can be shown to support the conservation effort and result in sustainable development it can be classed as ecotourism.

6.4 Sustainable tourist development.

The World Commission on Environment and Development (WCED) defines sustainable development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" The goals of sustainable development are three fold: to combat poverty, improve the quality of life and protect the environment (Owen *et al.*,1993). Owen *et al.*(1993) emphasise that Sustainable Tourist Development should be a means to achieve economic development in the local community where it is based. As a proviso, intrinsic cultural and natural values take precedence to their value as tourist products and should not be compromised.

The concept has been criticised by Butler (1991) who argues that the notions of sustainable development and the natural evolution of tourist sites are mutually exclusive. For example he points out that tourism to certain destinations is an evolutionary process, as is described by that author's logistic growth model for tourist development. He goes on to say that with increasing visitor numbers all associated aspects of it are liable to change. As sustainability implies stability and permanence there is inherent conflict in trying to blend these two concepts together (Butler, 1991).

Butler's tourism model appears to represent "expansive economic growth" as defined by Peet (1993) which is in conflict with sustainable development. For example with ever increasing consumption (seen in terms of rising visitor numbers) met by ever increasing production (seen in terms of the development of more tourist products to cater for wider visitor expectations as the character of the destination changes), the site carrying capacity is rarely respected. When this carrying capacity is reached, one of two things can happen. Firstly it may be broken through, either through innovative exploitive techniques, or the business will decline and move to "unexploited" carrying capacities (Peet,1993). The former is represented by the "rejuvenation phase" of tourist development as represented in Butler's model. However unlike "expansionist growth", "developmental growth" is compatible with sustainable development and this is what tourism operators should aim for. For example, developmental growth occurs when resource use does not increase in volume but increases in efficiency. An economic strategy based on this development principle will eventually lead to the formation of a "steady state economy". Here energy inputs into the system are closely matched by energy outputs, mirroring natural ecosystem energy flows (Peet,1993).

In this light, the limits to growth for the ecotourism operator could be defined when the the "degree of naturalness" or the set carrying capacity of the attraction is compromised. As suggested by Butler's model, at this point the site would be expected to evolve and to be developed in such a way as to cater for greater visitor numbers and a different class of ecotourist, namely one that does not demand a the same degree of naturalness. Alternatively, once this carrying capacity broken, the destination could either be retired from use until the site recovers or further developed through interpretation and site hardening.

The success of ecotourism depends on a sustainable management regime. If the tourist operator runs his/her business aiming to increase production to infinitum always exceeding the limits to growth he/she will certainly "deplete" the very resource on which his/her venture is based. In this case the operation is unsustainable and cannot be classed as ecotourism according to Buckley's and Bottrill's framework. Sustainable

development is incompatible with expansionist growth but not developmental economic growth as described by Peet (1993). Indeed true sustainability can only be achieved in a "steady state" economy. In this light, ecotourism can only truly reach its goals if it embraces such an economic line of thinking.

6.5 Applying the ecotourism framework to the Quail Island restoration concept

As Quail Island is connected to the mainland at low tide it would be prudent to treat it as having both the characteristics of a "mainland habitat island" and a true island (see Chapter 1.2). For this reason a synthesis of experiences gained from true island and mainland habitat island restoration would be desirable to develop prescription for the potential role of the community on Quail Island. To accomplish this I have employed comparative study methodology as defined by Pearce (1993). This involved the review of two restoration projects: one on the mainland, the Hinewai Reserve on Banks Peninsula and the other, Tiritiri Matangi Island in the Hauraki Gulf. Both restoration projects engage participative recreation as one of the means to help fund their activities. I have examined them to see how well they conform to the ecotourism paradigm and I have drawn out the elements that make them successful.

6.5.1.0 Hinewai Reserve

Hinewai Reserve is a 980 ha reserve in the southeast corner of Banks Peninsula. It is privately owned by the Maurice White Native Forest Trust and managed by botanist Hugh Wilson. The *raison d'être* of the reserve is for the "...protection and restoration of native vegetation and wildlife and conservation values are paramount "(Wilson, 1992 p.1). About 40% of the reserve is covered in native bush, the rest is occupied by exotic weeds, predominantly gorse and broom. The reserve is managed through the principles of the Minimum Interference Management strategy (McCracken,1993). In this way gorse and broom serve as native forest nurse crops eventually being shaded out by forest

species. The reserve is surrounded by private farmland. Hinewai is seen by neighbouring landowners as an uncontrolled source of noxious weeds. Hinewai is obligated by the local council to ensure that gorse does not spread outside the boundaries of the reserve.

6.5.1.1 Management objectives

The administrative and operational perspective is aimed at being as environmentally friendly as is practical. Management does not allow the use of pesticides, herbicides or machinery on the reserve. All tracks and boundaries are kept clear of gorse by hand. Participation in Hugh Wilson's "grass roots conservation programme" is the unglamorous task of grubbing gorse. Visitors are also encouraged to support the programme with donations. In relation to control of tourist behaviour there are only two strict codes to follow: stick to the tracks and light no fires. Walking off the tracks will disturb regeneration and fire will set back the forest recovery and stimulate further gorse growth. There has been no need for the setting of carrying capacities as demand is still quite low (Hugh Wilson pers com). No conscious education programme is required, as visitors are for the best part environmentally educated.

6.5.1.2 Visitor profile

The participant perspective shows a high degree of personal commitment to the project. Visitors to Hinewai are usually small work parties between 5-8 and affiliated with local conservation-environment groups or have some personal contact with the manager (Ralf Trabour, pers com). The principal motives for participation are two fold: to enjoy the surrounding and to participate in an exciting and viable conservation project (Karen Delores, pers com). It is also possible that Hugh Wilson's charisma and personal philosophy is an attraction in itself (Ralf Trabour,pers com).

6.5.1.2 Facilities

Accommodation for ten or more people is provided. The reserve is part of the Banks Peninsula Track and the visitors centre is open to backpackers. A night's accommodation costs approximately \$10, although it is possible to work in exchange for a free night. The enhancement of the tourism side of the operation is not a priority although the potential is recognised. Self composting toilets and a grey water disposal system have been installed. Electricity is drawn from the national grid and there are no plans to develop alternative sources. This is because installations may consume valuable space used for restoration (Hugh Wilson, pers com)

The Hinewai project meets most of the ecotourism criteria described by Bottril (1993) and Buckley (1994). The operation is sustainable and it has the potential to be profitable, however this is not the intention of the reserve. The central purpose is to practise conservation and community interests are secondary to this.

6.5.2.0 Tiritiri Matangi Island

Tiritiri Matangi Island is located 3.5 km from the Whangaparaoa Peninsula in the Hauraki Gulf and 28 km from the city of Auckland. It is administered by the DoC and is part of the Hauraki Gulf Maritime Park. The Island has an area of 220 ha, and was originally covered in coastal broadleaf forest. It has been extensively used for grassland farming and was repeatedly burnt. The last stock were removed in 1972.

6.5.2.1 Management objectives

Tiritiri Matangi Island is an "open access" restoration island (Atkinson, 1990). Its central role is conservation advocacy through public contact with threatened species and participative recreation. The principal stated management goal is "...to provide a suitable

habitat for some of our rarer and endangered fauna and flora, where people especially Aucklanders can view them." (Department of Lands and Survey,1982). With large numbers of visitors and volunteers it was necessary to impose a relatively strict management regime. In this way the conservation value of the island should not be compromised by the negative environmental impacts associated with nature-based tourism. The management plan stipulates seven main factors that ensure the attainment of the restoration goal:

- i) the island must be accessible to visitors and volunteers
- ii) there must be supervision
- iii) visitors must be made aware of their impact on fauna and flora
- iv) visitor facilities should be provided
- v) fires are banned and predators stopped from entering the island
- vi) there should be co-operation and participation of various environmental groups in the implementation of the plan.
- vii) there needs to be continual monitoring of flora and fauna, and feedback should be used to re-evaluate existing policies.

6.5.2.2 Facilities

Electricity is generated with the use of solar panels. In the event that insufficient power is available, a diesel generator switches on automatically. The Dry Vault Toilet complex at the beach near Wattle Valley uses passive solar heating to generate warm air flow. There is as a result no smell or water used and the toilet is never emptied.

6.5.2.3 Visitor profile

In 1990 Tiritiri Island received over 5000 visitors and most of these were volunteer workers (Galbraith,1990). The volunteer group, the Supporters of Tiritiri Matangi (Inc), was founded in 1988 and is made up of representatives of the general public and such

organisations as the Royal Forest and Bird Protection Society, New Zealand Ornithological Society as well as service and interest groups. Volunteers are of all ages and cover the social spectrum (Galbraith,1990). The objectives of the group are to promote and ensure that the project continues and succeeds. This includes, financial, material and physical support. Examples of the role the public can play in such projects are the nest sites built for little blue penguins by children of the Kiwi Club in Auckland, saddleback nest boxes built by high school students and a board walk that follows the contours of the land, donated by a local carpenter. The estimated value of volunteer contributions in 1990 was approximately \$1 million (Craig,1990). Such people are motivated by a genuine concern for the local and global environment. Furthermore local people with no affiliations to conservation groups were organised by local radio stations in planting programmes. Many people identified personally with the trees they planted and were willing to return "...to see how their trees are growing.." (Bellingham,1990). In terms of conservation this ensures a continuing public interest and support, in terms of tourism it promotes the likelihood of a return visit.

6.5.2.4 Tiritiri restoration philosophy

The prime objective for Tiritiri is advocacy through public participation in conservation. As this was paramount, attempting to recreate something precisely resembling pre-settlement conditions and respecting the genetic provenance of donated seedlings was not a priority. Firstly this was because placing too many restrictions on the type of plants donated may have alienated the public from the project. Secondly the pre-settlement goal is largely unrealistic (Simberloff,1990; Chapter 2). This has meant that the island's planted forest with its mix of species from outside the island's ecological district and seeming disregard of species site requirements, has an artificial, but well meaning appearance. This is particularly noticeable in the planting of seedlings in rows. Also central ridge tops were kept bare to retain views of the rest of the island and the Hauraki Gulf. The planting strategy succeeded in establishing the beginnings of a low forest canopy. Despite the shortcomings of the planting strategy, productive habitat

for numerous translocated avifauna populations such as whitehead, saddleback, robin, saddleback, takahe etc has been provided. The Tiritiri project shows that large-scale, public driven restoration projects can be successful.

In summary the Tiritiri project appears now to meet many of the described requirements of ecotourism. It is a sustainable tourist resource that works for conservation. Although it is not the expressed desire to be a tourist resource and to participate in sustainable development it is a natural consequence of conformity to the ecotourism framework.

6.5.3 Comparison of Hinewai and Tiritiri Matangi Island

The most obvious difference between the two case studies are the management goals. Hinewai's priority is to let the reserve recover naturally without interference or help from the use of chemical pesticides or even machinery. Tiritiri actively seeks the active involvement of volunteers for advocacy and pesticides donated by corporations, were used in the initial stages.

Hinewai requires only enough people to maintain the tracks and boundaries. In comparison to Tiritiri Matangi Island, Hinewai is low profile and workers can be more or less selected by the manager. This reduces the threat of irresponsible behaviour leading to negative impacts. The rehabilitated forest at Hinewai could be considered more 'authentic' compared to replanted one on Tiritiri. This may have some future bearing on the selection by those tourists who seek an authentic experience which characterises the alternative tourist movement (*cf* Cohen, 1988; King and Stewart, 1996). However for the Tiritiri project the conservation advocacy achieved through public participation outweighs the costs of authenticity.

The distinctive successful elements of the Hinewai programme are perceived as the following. A focused conservation goal, the MIM strategy, autonomous management,

environmentally friendly infrastructure and a small number of committed volunteers requiring little control and creating negligible impacts. The distinctive successful elements of Tiritiri are perceived as, taking advantage of the public's desire to participate in conservation for restoration and advocacy, carefully thought out code of volunteer control and conduct. Taking these factors and the results of the scoping exercise (Chapter 5) into consideration, guidelines for the administration of a community based restoration project on Quail Island have been formulated. These are presented in the proceeding section.

6.6 Community participation prescriptions for Quail Island

An incorporated society or a charitable trust is recommended as the ideal corporate entity to achieve co-operative relationships between the Department of Conservation and the community (Fuller, 1994). The aims of this trust should be worked out in a process of negotiations between the stakeholders. This will ensure acceptance and ownership of the process. However the following aims are suggested to provide some general guidelines, they are not intended to be final.

- i) To restore and enhance the natural forest recovery processes on Quail Island providing a habitat for some locally extinct avifauna and threatened plants.
- ii) To preserve and enhance the cultural significance of the island for local indigenous population.
- iii) To provide an avenue of support to redress breaches of the Treaty of Waitangi and achieve sustainable development.
- iv) To preserve and enhance the European historic sites.
- v) To foster community participation in conservation

It is envisaged that all stakeholders should be represented. The principal groups have been identified as the following: Rapaki Runanga, North Canterbury Branch of the Royal Forest and Bird Protection Society, The Historic Places Trust, The North Canterbury Conservation Board and the Department of Conservation.

The Trust should manage all aspects of the restoration. This should include the following tasks:

- i) The identification of interest groups and individuals to be involved in the implementation of the project.
- ii) The setting up of work programmes for community involvement.
- iii) Fund raising through donations and corporate sponsorship.
- iv) Maintenance of consultative links between local and regional government and the restoration ecology scientific community for comment and advice.
- v) Engage the services of research students to monitor the process of the restoration.
- vi) Determine success of the applied restoration management strategies.

The trust should be run under the five principles of sustainable tourist development described by Owen *et al* (1993) and presented below with application to Quail Island. The principles can be used as a touchstone to evaluate tourism projects and some of them (i.e. ii-v) may also be employed as criteria for the success of the restoration project (Chapter 9.4).

- i) *Tourism is a potent economic activity which brings tangible benefits to the host community as well as to the visitor; however, tourism is not a panacea and must form part of a balanced economy.*
- ii) *The physical and cultural environments have intrinsic values which outweigh their values as tourism assets; their enjoyment by future generations and long term survival should not be prejudiced by short term considerations.*
- iii) *The scale and the pace of tourism development should respect the character of the area. Value for money and a high quality tourist experience should be provided.*
- iv) *The goal of optimum long term economic benefit to the community as a whole should be pursued, rather than short term speculative gain for only a few.*
- v) *Tourism development should be sensitive to the needs and aspirations of the host population. It should provide for local participation in decision making and employment of local people.*

6.6.1 Quail Island as a Biosphere Reserve

In the following passages I argue that a convenient way to mediate the concerns of the community with the restoration goal is through the application of the Biosphere Reserve concept. It should be stressed that this is not to say this is the only means, as ultimately the way the project will be administered rests in the results of the negotiation process between stakeholder groups.

The Biosphere Reserve concept first emerged from the UNESCO's Man and the Biosphere Programme (MAB) in 1968 as a means to integrate development with the use of natural resources and conservation (UNESCO, 1974; Batisse, 1986; Dingwall and Simpson, 1988). The concept remained ill-defined for nearly two decades before it was agreed that it must be a synthesis of conservation, sustainable development and research (Batisse, 1986). It is thus defined as *"...a place containing land and/or marine areas, which may be in public and/or private ownership, with a range of uses from protection to intensive utilisation, where an active programme of research, monitoring, training and education is conducted to demonstrate interrelationships between people and nature and to guide the sustainable use of resources"* (Dingwall and Simpson, 1988). In order for a site to be designated a Biosphere Reserve, a nomination by the New Zealand Man and the Biosphere national committee must be prepared in collaboration with interested bodies. It is then sent to the UNESCO International Co-ordinating Council for approval. If it is accepted the site is certificated by the council (Dingwall and Simpson, 1988).

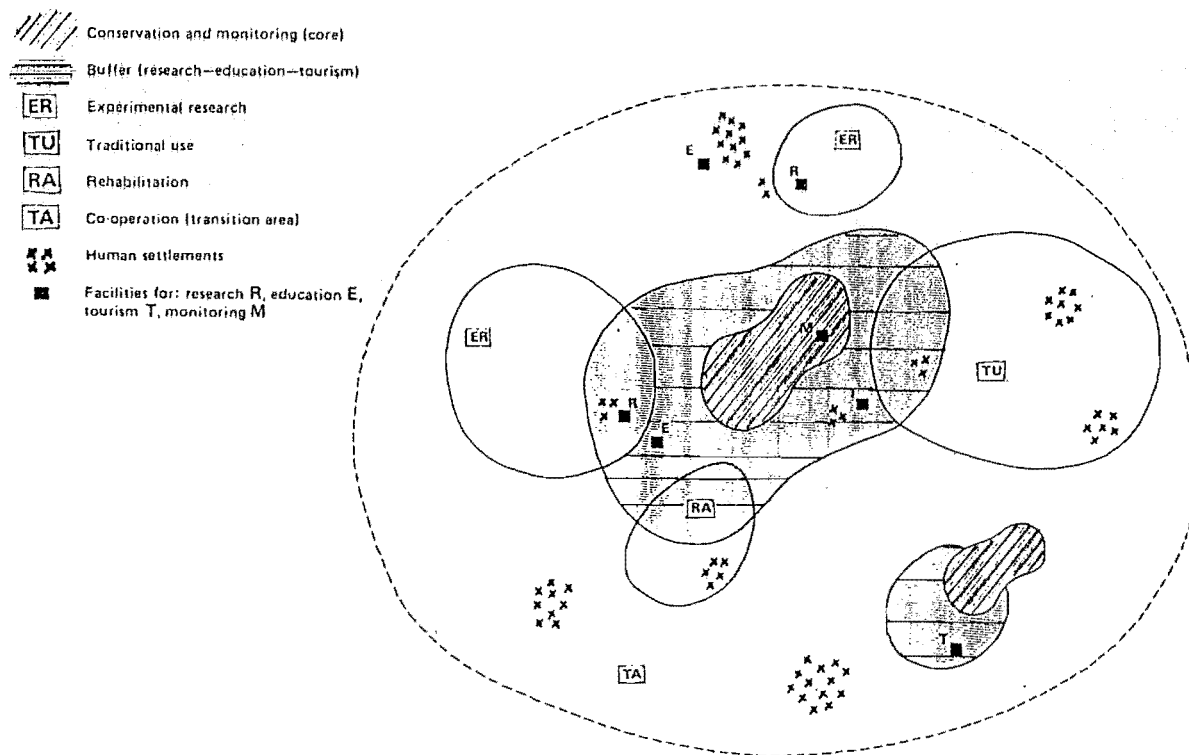


Figure 6.1 Schematic distribution of biosphere reserve functions (after Batisse, 1986)

I believe that the Biosphere Reserve concept is suitable for the proposed Quail Island restoration project for the following reasons. Firstly the Biosphere Reserve concept is comparable to the ecotourism paradigm, differing only in that the developmental role or resource use in ecotourism is restricted to tourism. For example it is a synthesis of three major concerns: i) a need to reinforce the conservation of genetic resources, that is to play a conservation role. Both Bottrill (1993) and Buckley (1994) insist that conservation is integral part of ecotourism, without it the paradigm falls apart.

It is typical for Biosphere Reserves to be centred around an existing forest that has significant biological values (Figure 6.1). The core must also be large enough to practise *in situ* conservation and provide touchstones for the measurement of long terms

changes in the biosphere (Batisse,1986). Quail Island covers some 86 ha. A core of forest at the most 80 ha could be restored. The rest would constitute the buffer zone. Stuart and O'Donnell (cited in Crossland, 1996) suggest that an area of 80 ha on the Port Hills, could support at least six to eight viable populations of forest bird. It is uncertain at this early stage whether the island could provide sufficient habitat for viable populations of all the species ear-marked for translocation (Chapter 8), this remains a subject for further research.

It is not usual for Biosphere Reserves to be formed around sites in need of large scale restoration, and this proposal is unorthodox. This, I believe, is because the importance of ecological restoration for the conservation of biodiversity has only recently been acknowledged (Cairns, 1988; Robinson and Handel, 1993; see also Hobbs 1993 , Awimbo *et al*, 1996 and Norton, 1996; Chapter 1.3). However it is proposed that the restoration zones (ie "forest cells" Chapter 8) and the fragile coastal areas could legitimately constitute the core. With the establishment of a canopy and increasing biological values, the core should be protected by elevating it from Recreation Reserve to Scenic Reserve or Scientific Reserve (*cf* the entire island being elevated from "Restoration Island" to "Multiple-Use" or "Open Sanctuary Island", see Atkinson (1990) for definitions) . Eventually, it is hoped that the reserve will come to resemble a traditional Biosphere Reserve.

ii) A need to blend land resources development with environmental protection, that is to play a developmental role (Batisse,1986). Sustainable development is a vital part of the ecotourism paradigm. In the Biosphere Reserve opportunities for sustainable development are provided within the buffer zone surrounding the protected core. Activities must be compatible with the preservation of the core and are restricted to education, tourism and recreation and research (Figure 6.1). In regards to Quail Island the popular beaches and Walkway could remain under Recreation Reserve status and serve as a buffer zone. This zone could meet the recreational needs of the public while providing opportunities for ecotourism concessionaries. Leases to operate ventures within recreation reserves must be appropriate and are issued at the DoC's discretion

(Mason,1992). Parts of the periphery of Quail Island could support small ecotourism ventures, such as an environmentally friendly backpackers lodge, nursery and white flippered penguin colony. The expressed aims of these facilities would be to fund the establishment and continued running of the restoration project, while providing long term employment for the local community.

It is a further requirement that the buffer should include one or some of the following designated areas: a) Places where methods of sustainable development can be demonstrated, that is experimental research areas (ER). The practice of ecotourism should be regarded as an experimental demonstration of sustainable development and there may be no need to provide others. b) Examples of a harmonious landscape resulting from traditional landuse patterns, that is traditional use areas (TU). It is possible to provide sites for traditional Maori agriculture and cultural harvest on the island.

iii) A need for an international network of reserves for research and monitoring of representative examples of the biosphere, that is to play a logistic role. Monitoring is an essential requirement of ecological restoration and monitoring in this context equates to research. For example, it was argued in Chapter 1.3 that the practice of conservation in New Zealand is restorative and the practice of restoration requires monitoring and through monitoring we are in fact hypothesis testing (Chapter 9.0). New Zealand does not have as yet a Biosphere Reserve (Dingwall and Simpson,1988) and the creation of one will connect this country into the development of this international information network.

Finally the concept provides a ready made code of practice and set of goals, that not only endorses the suggested strategy but allows the administering body to benefit from the experience of existing projects overseas. Lastly the concept is "politically neutral", that is, it does not serve any other purpose than the stated objectives of sustainable development and conservation. This provides a basis to avoid potential conflict between the contributing parties of the Trust.

6.7 Conclusions

In order to achieve the ecological restoration goal for Quail Island it is important to mediate and respect the wishes of the principal stake holders. Owing to the vital and symbiotic links between the public and conservation in New Zealand it would be ill-advised and counterproductive to try to exclude the stakeholders and the public from the project. Public involvement in restoration projects is frequently at the level of participative recreation. In this chapter it is argued that this form of recreation is akin to the modern definitions of ecotourism. Ecotourism can be thought of as an expression of sustainable development and conservation through tourism to natural places.

Ecotourism attracts a lot of criticism and cynicism. The most salient criticism is the apparent conflict between sustainable development and the natural evolution of tourist sites. An argument is put forward that this scenario is an example of "expansive economic growth" and it can only be overcome through an adoption of "developmental growth" and "steady state economics".

A comparative study of two case studies of successful restoration projects that engage participative recreation was conducted. The purpose of this exercise was to highlight the successful elements and to develop an appropriate strategy for Quail Island. It is concluded that the best way to mediate the concerns of the principal stakeholders in Quail Island and the proposed restoration goal is through an ecotourism framework. The most workable administrative structure is the commonly used charitable trust. The group should have a focused conservation goal and be mindful of the cultural context of the island. It is suggested that the project could be partly funded through a variety of sources including sponsorship, donations of time and labour and other ecotourism ventures. Funds raised through visits to a colony may be used to provide employment for the local *runanga* at Rapaki and partially support the restoration project. In fact the two objectives become synonymous. All activities should be run in accordance with the five principles of sustainable tourist development. If these are adhered to there would be mutual benefits for both the local community and the assured protection and

continual amelioration of the resource on which such ventures are centred. Finally it was argued that the proposed strategy is comparable to and compatible with the Biosphere Reserve concept developed by UNESCO.

Chapter 7:

Restoration Constraints and Vision

7.0 Introduction

The formation of a realistic restoration vision results from the interplay of environmental filters and restoration constraints. Restoration constraints may be defined as those elements in the natural and cultural environment that restrict or impede the natural operation of the desired array of environmental filters. In other words restoration constraints may be considered undesirable environmental filters. However depending on the type of restoration goal, what is considered a constraint for one project may be considered a filter for another. For example if a grassland ecosystem is desired for Quail Island then a maintenance of a high rabbit population is necessary to select out native forest seedlings. If this is not the goal then the rabbit population becomes a constraint.

The purpose of this chapter is to briefly examine the constraints operating on Quail Island that el discuss philosophical constraints. In section 7.1 I discuss the problems the DoC attitude towards the restoration initiative may have on the project. In section 7.2 I discuss biotic constraints posed by introduced mammals such as the rabbit, mustelids and rodents. Finally in section 7.3 the vision statement for Quail Island is delivered.

7.1.0 Cultural and management constraints

7.1.1 Attitudes of the Department of Conservation Reserve Managers

From the evidence reviewed in Chapters 3.3.4 and 4.1, it is likely that Quail Island was forested prior to human settlement. The tussock grassland that greeted the early European settlers appeared natural, but in reality could only be maintained through frequent disturbance through frequent burning (Wilson 1987,1992a). Those areas

considered too harsh for European pastoralism were believed by the early settler to be also too harsh for forest. This view was endorsed by Laing (1919) reiterated later by Griffiths (1974). Such outdated beliefs appear to have shaped many of the past the management policies of Quail Island up to the present day. This attitude taken by the Department of Conservation reserve managers is a serious constraint to allowing a restoration project to proceed.

7.2.2 Weeds

The DoC is required by legislation to control noxious weeds on the land it manages. In particular under the Reserves Act 1987 it must keep land clear for recreational purposes and species such as broom and gorse are targeted. It is however well documented that these two species perform the role of nurse species in a vegetational change sequence leading to a mahoe dominated broadleaf forest (Williams, 1983; Wilson, 1990; McCracken, 1993). If gorse and broom were left unchecked they would eventually cover most of the island and a forest canopy could return in approximately 25-30 years. In order to achieve the same goal without the benefits of this nurse crop, the process of restoration would be considerably slower and more expensive (cf McCracken, 1993; Wilson and Wright, 1995; Chapter 8.2).

Other introduced species pose a more serious threat to forest recovery; all are woody and able to colonise grassland (Table 7.1) and they should be targeted for control before the process of planting begins. Nevertheless for some other species it is more difficult to make a decision. For example macrocarpa and monterey pine provide good shelter and act as nurse crops for species such as ahiraho (*Olearia paniculata*). However they may compete with pre-colonial planting and should be controlled at a seedling level only. Most of these trees are overmature and will eventually die. Furthermore as it is explained in the following section, fallen trees have advantages for forest recovery.

Weed control is potentially very expensive and so prevention of future invasion is

preferable. This involves two steps. Firstly the removal of invasion sources both on the island and from the mainland. Secondly the elimination of potential sites of colonisation, such disturbance sites. This could be achieved through the planting of pre-colonial species in these sites (David Norton, pers com).

Table 7.1 Weed species present considered a serious problem (after Porteus, 1990; Wilson and Wright, 1995)

<i>Clematis vitalba</i>	Old man's beard
# <i>Crataegus monogyna</i>	Hawthorn
# <i>Berberis glaucocarpa</i>	Barberry
# <i>Lycium ferocissimum</i>	Boxthorn
# <i>Acer pseudoplatanus</i>	Sycamore

Species of a less serious problem

<i>Rubus fruticosus</i> agg.	Blackberry
<i>Lonicera japonica</i>	Japanese honey suckle
# <i>Chrysanthemoides monilifera</i>	Boneseed
<i>Fraxinus excelsior</i>	Ash
<i>Hedera helix</i>	Ivy
<i>Lavatera arborea</i>	Tree mallow
# <i>Cupressus macrocarpa</i> (seedlings only)	Macrocarpa
# <i>Sambucus nigra</i>	Elderberry
# <i>Pinus radiata</i> (seedlings only)	Monterey pine
<i>Cotoneaster</i> spp.	

Species present on Quail Island

7.2.3 Removal of fire hazards and rabbit lairs

Current management policy for Quail Island results in the removal of fallen trees as these can be regarded as fire hazards. However fallen trees provide valuable seedling safe sites for seedlings and supply valuable shelter, perches and habitat diversity for birds. Most pre-colonial species are fire resistant and planting around fallen trees will not only enhance their value for wildlife but act as a fire retardant. Broom and gorse are both highly flammable and will pose a fire risk. For this reason it would be necessary to have a fire control strategy devised from the outset of the restoration project. Essentially this could amount to a continuation of the complete ban on fires and strategically located freshwater collecting systems for fire fighting (*cf* Wilson and Wright, 1995).

7.2.4 The history of problems associated with the Corsair Bay restoration programme

Residents were frustrated with the loss of planted seedlings through theft and accidental destruction during a Banks Peninsula weed control exercise. This has left residents reluctant to participate in another restoration project. Clearly the advantage of Quail Island is its relative isolation and its reserve status which affords more control over the public and management.

7.3.0 Mammals

7.3.1 Predatory mammals

Quail Island supports a community of predatorial mammals (Chapter 3.4). It would not be sensible to translocate avifauna that cannot co-habitat with these animals. The birds expected to be suitable are volant and relatively predator resistant. However it will be necessary to control these animals to enable bird populations to establish and increase

in numbers. Once this has occurred constant control measures should be maintained where sustainable. For example this concept plan includes the re-establishment of a penguin colony (Chapter 8.10). It is suspected that the last penguin colony on the island was destroyed by ferrets and it is probable that they may pose a similar problem in the future. In addition to permanent trap stations, it may be necessary to install a predator proof fence to protect this valuable species for its own sake and as an ecotourism resource (Chapter 6.6). Secondly predator control on a "mainland habitat island" such as Quail Island can only ever be temporarily successful. This is because after control programmes there will always be other individuals to fill the place of those eradicated. In this light it is expected that pest control will need to go on indefinitely (*cf* Brockie, 1991; Saunders, 1990).

7.3.2 Rabbit (*Oryctolagus cuniculus cuniculus*)

In open fields birds are attracted to woody vegetation which provides shelter and perch sites (Reay, 1996; McDonald and Stiles, 1983; McClanahan and Wolfe, 1987; Robinson and Handel, 1993). This can result in an exponential increase in woody plant densities and a concomitant number of visits by birds (Robinson and Handel, 1993). High rabbit numbers act to suppress forest recovery by inhibiting the "first pulse of woody recruitment" (Robinson and Handel, 1993) thus maintaining the grassland meta-stable state. Rabbit density is particularly high on the island scoring a rating of '4' on the MacLean Scale. Neighbouring mainland areas score between a '2' and '3' on the same scale (*pers. obs.*) (Appendix 5). According to Bell & Vietch (1990) and Miller *et al* (1994) in order to ensure the success of a restoration project, no planting should be considered until all browsing mammals are removed. Rabbits cause considerable damage to revegetation plantings by browsing and digging out newly planted seedlings (Porteus, 1993). On Quail Island post-colonial woody species such as elder, gorse, broom and flowering currant tend to be overlooked by rabbits, which may have some benefits for the recovery of native forest.

The attempts to revegetate the island in 1983 were severely hampered by rabbits (John Watson, Stuart Moore and John Trotter pers com). It is held that extirpation of rabbits will only lead to re-invasion from the mainland. However control is carried out when numbers are considered excessive (John Trotter, pers com). As it is believed that the population cannot be controlled, the DoC has no up to date management plan for the island (John Watson, Stuart Moore and John Trotter pers com).

It is the purpose of the following section to examine the validity of the assumption that the rabbit population is open and control is futile. The first wild rabbit was spotted in Canterbury on Quail Island in 1851 (Ward, 1851). It is still uncertain whether rabbits were initially deliberately introduced or whether they made their way across the mudflats at extreme low water spring tide (Walker, 1970; Jackson, 1990; Wilson, 1992).

Owing to the presence of a semi-permanent channel between King Billy Island and Moepuku Point which may act as a migration barrier, Walker (1970) considers the population to be "closed." Rabbits have been observed on the mudflats near the southern beaches region and droppings have been found on King Billy Island (pers obs).

At about the turn of the century rabbit shooting became a commercial enterprise on the island (Jackson, 1990). However between 1918-1926 the rabbit population was severely reduced in numbers by hunting. They were re-introduced for sport in 1942 and eliminated by 1944. According to Walker (1970) they were not seen on the island until 1966. Their continual reappearance could be due to three possible causes: i) deliberate release to set up a clean (unpoisoned) population, ii) natural migration across the mudflats under population pressure from the mainland due to a lapse in control efforts at that time, or iii) they may have spread from individual rabbits that escaped the notice of observers (Walker, 1970).

In conclusion, if the population is open, it is likely that emigration to the mainland occurs during times of population pressure and resource depletion. If this is the case the DoC is obliged to control this population. It appears from the evidence that it is

indeed possible to contain the population for anything up to 20 years with a concerted control regime. This would be sufficient time to allow plantings to establish. This will have a flow on effect of "crashing" the stoat and rat populations. From the point where the browsing influence is minimalised, native forest regeneration will rapidly occur. Revegetation could begin at this point. Once a closed canopy, it is expected that the island will no longer be suitable for rabbits.

7.4 Restoration vision for Quail Island

The vision statement is a synthesis of restoration potentials and constraints. It is used to provide a direction for the restoration process and contributes to the restoration goal as a functional conservation postulate. The vision for Quail Island is as follows:

In pre-settlement times mixed broadleaf-podocarp forest extended from the seashore to the highest peaks of Banks Peninsula. It is likely that Quail Island was also forested at this time and it could be classified as a (sub-humid) maritime-cool temperate mixed broadleaf-podocarp forest.

The conservation estate is made up mainly of land that was considered to have little economic potential, usually of low fertility and confined to upland and alpine areas (James, 1990; O'Conner *et al*, 1990; Park, 1995). The most productive lowland areas were cleared of forest and used for agriculture. Fecundity in native birds may be dependent on forest phenology. Highly productive forests have been shown to allow increased reproduction which may offset losses through mammalian predation. This was found to be the case with the yellowhead (*Mohua ocrecephala*) in the Eglington Valley (Elliot, 1990), the saddleback (*Philesturnus carunculatus*) on Tiritiri Matangi Island (Craig, 1994) and the kokako (*Callaeas cinerea wilsoni*) in the Mapara reserve in the central North Island (Bradfield, 1993).

There is evidence to suggest that forest bird communities engage in an internal

migration from the cooler upland zones to warmer lowland coastal zones in the winter (cf Wilson *et al*, 1988). With the loss of lowland forests these migrations have been truncated and many native birds have been confined to their winter habitat and the limits of their natural range.

Quail Island is abandoned semi-fertile crop and pastureland. It is climatically and edaphically similar to the surrounding mainland. If the island's former maritime lowland forest and scrub vegetation could be ecologically restored, in association with mainland corridors, it could form a valuable maritime lowland component of a large and interconnected reserve system in the Lyttelton Harbour Basin. Effectively this would increase the size and the habitat diversity of each reserve, adding to it a dry matai-broadleaf maritime forest element. It is hoped that an appropriate locally extinct avifauna can be re-introduced to the island and into the reserve system.

The restored forest should be able to support a variety of predator resistant and locally extinct pre-colonial avian species. As the island is connected to the mainland at low tide it is accessible to predators and possibly accessible to rabbits, it should therefore be managed as a "semi-mainland habitat island." It is envisaged that predator control may be necessary, especially in relation to protection of white flippered penguin and petrels colonies.

7.5 Summary and Conclusions

In this chapter I have examined the main constraints to achieving the restoration goal. The most significant are the attitudes held by the DoC against the viability of the project. This relates to the belief that the rabbit populations are "open" and uncontrollable due to the risk of reinvasion from the mainland. It is argued that if the population is open, it is likely that emigration to the mainland occurs during times of population pressure and resource depletion. If this is the case the DoC is obliged to control this population. Control is achievable and has been done in the past with long

term suppression of up to 20 years being achieved. There would be sufficient time to establish a canopy and make the island uninviting to rabbits. The elimination of rabbits will probably crash the mustelid populations thus improving the chances of reducing their populations further.

Chapter 8:

The Restoration Process

8.0 Introduction

This chapter begins with a statement of the restoration goal. This is followed by a brief overview of the possible management options available to achieve the restoration goal within the limits of the constraints and potentials. This leads on to the development of a medium management restoration approach that aims to mimic and accelerate natural patterns of forest recovery occurring on Quail Island. This is followed by lists of ecologically appropriate species for planting in designated sites presented in section 8.2. The principles associated with planting out, the collection and propagation of appropriate forest propagules, post planting maintenance and planting trials are discussed in sections 8.3-8.6. In section 8.7 lists of suitable non-woody species for translocation are provided. Section 8.8 lists ecologically appropriate vertebrate fauna for possible translocation to Quail Island.

One of the first active steps in restoration is to remove the impediments to forest ecosystem recovery (Atkinson, 1988; O'Conner *et al*, 1990; Towns *et al*, 1990; Vietch and Bell, 1990; Hobbs and Norton, 1996). As it was established in sections 3.4 and 7.3, the presence of the rabbit and unknown numbers of mammalian predators that are the principle inhibitors of pre-colonial forest recovery. The proposed reforestation technique presented in this chapter is written with the view that rabbits have been removed and that it is unlikely that reinvasion will occur before a canopy can be established. However owing to the close proximity and connection to the mainland the removal of predators such as mustelids and rodents is far more problematic. To this end Quail Island should be treated as a Mainland Habitat Island (*cf* Norton, 1993), in which predators are maintained at tolerable levels until a technology is developed to eliminate them completely, or where it can be shown that a stable equilibrium between them and threatened pre-colonial species exists.

8.1 Restoration goal statement

The restoration goal is an embodiment of the findings of the preceeding chapters and forms the ideological basis for the restoration process. It is as follows:

To allow nature to determine the final forest structure and function, while ensuring that a predominantly pre-colonial species composition of plants and avifauna is achieved. The restoration process should be designed to accelerate and reinitiate pre-colonial forest recovery processes. Contemporary vegetation change sequences should be allowed to proceed with enhancement from pre-colonial elements.

8.2 Management Options

There is a continuum of approaches to restoration ranging from minimal interference to intensive management. The object of this section is to find an appropriate blend of methodologies that best suits the Quail Island context.

8.2.1 The minimal interference approach

This requires that human intervention is limited to controlling those elements that may impede natural forest recovery processes, such as fire. This is the "do nothing" approach (Porteus, 1993 pp.166-167) which is akin to the Minimum Interference Management (MIM) strategy used on the Hinewai Reserve near Akaroa as described by McCracken (1993). The experience from the Hinewai Reserve has shown that through this strategy, natural forest succession is as rapid as direct planting. It is expected that a mixed podocarp broadleaf forest canopy could be attained in 20-30 years after the attainment of a gorse and broom canopy. Gorse seeds will stay viable in the soil for up to 30 years after which time they are no longer a part of the forest system (McCracken,

1993).

According to the scoring system developed by McCracken (1993), Quail Island has "low" to "good" native forest recovery potential through gorse and broom. Low potential prevails in the northern aspects and intervention will be essential. This will entail enrichment plantings and success is only assured in favourable seasons. On the southern side potential is good and recovery may or may not occur without the need for enrichment plantings.

This technique may have a number of disadvantages. Firstly there is likely to be opposition to the encouragement of the spread of gorse on public land (Chapter 7.2.2). Even though the advantages of gorse as a nurse crop is proven there is likely to be opposition to the use of exotics in restoration projects. Gorse in Canterbury does not appear to provide habitat for pre-colonial avian species. This is a disadvantage because of the urgency to provide suitable lowland habitat for threatened species. Furthermore without forest remnants to serve as propagule sources on the island the stands of gorse will persist longer than if they were present.

8.2.2 Intensive Management

This approach entails the eradication of all foreign elements and hand planting natives using the "blanket assortment approach" (Luken, 1990 p.141; cf Wilson, 1995). This requires that all forest species present in reference sites are planted out in pre-determined quantities and combinations. This technique is labour intensive and expensive. It often results in the planting of certain species in inappropriate sites resulting in the loss of many seedlings (Wilson, 1995).

8.2.3 The Medium Management Approach

This option is a synthesis of intensive management and the MIM strategy and it is the chosen restoration strategy for Quail Island. It simply involves intervention through the creation of seed sources in selected areas and the control of harmful weeds, while allowing gorse and broom to colonise open areas to create a nurse crop. Blending these techniques has the advantage of limiting human interference to maximise the role of nature, while still creating opportunities for participative recreation. In using this technique it is expected that a forest canopy could be attained in approximately half the time of a purely non-interventionist approach (*cf* Wilson and Wright, 1995).

Generally speaking there are three planting options: i) The "blanket nurse species approach" (Luken, 1990 p.141). This involves the active planting of a rapid growing nurse crop, such as the post-colonial tree lucerne (*Chamaecytisus palmensis*), directly into grassland over all the areas designated for restoration. This species has the advantage over gorse and broom as it is especially attractive to the native kereru which is a major native seed disperser (Porteus, 1990 p.101). Despite the advantages of this species, there may be opposition from restoration interest groups to the planting of introduced species. Furthermore the blanket planting of a single species creates a monoculture which may suffer from attacks from pathogens and herbivores resulting in larger losses than if a species assortment was to be used.

ii) The second possibility is to mimic old field succession through the "blanket" planting of an assortment of pre-colonial nurse species in various combinations in suitable restoration zones. Old growth propagules will be disseminated into this matrix naturally from forest remnants. However owing to the fact that Quail Island lies a relatively long distance from the nearest propagule sources (Chapter 3.3.3.3), this process will be relatively slow.

iii) Planting a mixture of both nurse and old growth species over the entire island. The disadvantage of the latter technique may be overcome by this technique. This has the

advantage in contributing to the maintenance of higher levels of pre-colonial vegetation throughout the restoration process, as well as creating an early habitat for birds and invertebrates. However it is more costly and labour intensive than the aforementioned techniques. For example it requires the cultivation of nursery stock and large numbers of seedlings. Secondly, as all the seedlings will need to be maintained over the following 2-3 years after establishment, this planting option is more labour intensive.

8.2.1 "The forest cell approach"

"The forest cell approach" represents a compromise between the aforementioned techniques and it is aimed at overcoming most of the problems associated with them. It is a technique invented specifically for Quail Island. It is designed to mimic and accelerate the natural pattern and processes of old field succession occurring on the island, Mansons Peninsula and elsewhere on Banks Peninsula (Chapter 3.3). For example, firstly it was recognised that old field succession is enhanced through vegetation and habitat complexity. Once cover is provided by a successfully established trees, shrubs or debris, they may act as "recruitment foci" (McDonald and Stiles, 1983) for other woody species dispersed by birds seeking shelter, perch sites and food. The process is reminiscent of "nucleation", first described in reference to the spread of alien species (Yarranton and Morrison, 1974). It is now being investigated as a technique for the accelerated restoration of degraded land (Robinson and Handel, 1993). Secondly natural recovery occurs in sites of greatest moisture accumulation, such as in southern facing drainage channels and breaks in the grassland matrix. Thirdly it was concluded that colonisation by forest species depends on proximity to seed sources (Chapter 3.3). Fourthly forest patches will invade grassland at the forest edge where grass swards are often shaded out creating spaces for seedling establishment. Species that are exposure-tolerant will create microclimate for forest interior species (Chapter 3.3.1.6; *cf* McDonald and Stiles, 1983). Finally on Tiritiri Matangi Island, it was found that forest and edge species alike could be established by planting them directly into

grassland, where they would receive sufficient shelter from the sward (Miller *et al*, 1994). Direct planting would also create a window through many of the environmental filters that would usually exclude certain species from these exposed sites (Neil Mitchell, pers com)

The following technique takes into account these factors. Forest cells are made up of a central core of mainly old growth species surrounded by a matrix of chiefly forest edge and shrubland species. The nucleus will be essentially collections of all the possible plant species present in old growth and second growth reference states (Chapter 4.2). They should be located chiefly in areas that receive the most shelter, and accumulate the most moisture. Such sites should include the southern slopes, gullies and within the areas enclosed by the shelter plantings and amenity trees. Owing to the shelter provided by landform and other site attributes such as tall grasses (*cf* Miller *et al*, 1994) it may not be necessary to provide each light intolerant canopy tree with a nurse plant. The matrix will occupy the more exposed areas surrounding the nucleus. It will be made up of hardy scrub, shrubland and treeland pre-colonial species. This should constitute a 100m buffer zone around the nucleus. Together the nucleus and the matrix make up a "forest cell."

It is expected that after 2-7 years canopy closure will occur (*cf* Porteus, 1993 p.141) within the cells, thus providing microsites for woody seedlings. Although gorse and broom could serve as a matrix, a pre-colonial scrubby canopy is preferred. This is to maximise the pre-colonial species input and to provide habitat for pre-colonial species that will not form beneath a gorse canopy. Birds and wind will disperse propagules from the nuclei to the matrix and from the matrix into the grassland. Cell coalescence will occur through dispersal of propagules by mobile links as they move in search of food between planting sites. This exchange should be encouraged by the establishment recruitment foci such as perches, woody debris and honey water feeders within and between the forest cells. Coalescence is also likely to be enhanced by the rapid spread of broom and gorse out from isolated pockets on the island and the dispersal of forest propagules into this natural matrix. Avian species present on Quail Island known to

spread pre-colonial seed into gorse and broom stands are listed in Table 8.1. If the current Quail Island management regime was to permit it, this could be achieved in approximately 5-10 years after the creation of the forest cells. In the absence of fire and other disturbance a complete low forest canopy across the island could be realised in a space of 25-30 years after the inception of the project. A full tall forest canopy could be achieved between 100-150 years.

Blackbird *	(<i>Turdus merula</i>)
Song thrush*	(<i>Turdus philomelos</i>)
Hedgesparrow*	(<i>Prunella modularis</i>)
Chaffinch*	(<i>Fringilla coelebs</i>),
Goldfinch*	(<i>Carduelis carduelis</i>)
Greenfinch*	(<i>Carduelis chloris</i>),
Redpoll*	(<i>Carduelis flammea</i>)
Yellowhammer*	(<i>Emberiza citrinella</i>)
Starling*	(<i>Sturnus vulgaris</i>)
Silvereye	(<i>Zosterops lateralis</i>)
House sparrow*	(<i>Passer domesticus</i>)
Kereru	(<i>Hemiphaga novaeseelandiae</i>)
* post-colonial species	

Table 8.1 Bird species known to disperse pre-colonial seed into gorse and broom stands. After McCracken (1993).

8.3.1 Forest cell creation

Three sorts of forest cell sites are proposed. Firstly those that are derived from the 1983 revegetation planting, secondly those second growth recovery sites and the broadleaf forest remnant on the north east coast and finally the gully systems on the island . There are three types of forest cells. Type A are those created in and around the pre-1983 and 1983 revegetation plantings described in section 3.3.1.1. Type B are those created in sites of natural forest recovery, such as in manuka and bracken stands. Finally, Type C are those created in the water drainage channels or the gully systems (Figure 8.1 and Table 8.2.)

It is envisaged that nuclei plantings will take up a maximum of approximately 10 ha , with matrix plantings making up approximately 23 ha. The microsites provided by stands of bracken, *Coprosma*, manuka and kanuka scrub should be taken advantage of. The procedure for planting in and around scrub has been described by Porteus (1993, pp.153-157).

Table 8.2 Forest cells for Quail Island

Type A : Pre-1983 and 1983 Revegetation Plantings

- 1) Visitors centre, generator shed, workers accommodation wool shed, visitors shelter
- 2) Equipment shed and picnic area at the Southern Beaches zone.

Fortunately the 1983 restoration plantings on the northeast, east, southeast and south coasts are in good condition and they can be readily enhanced with proper management. It is the plan to unite the scattered natives in these areas to form a single forest fragment nuclei. In each case full advantage should be taken of the exotic pine and macrocarpa cover provided.

Type B: Natural Forest Recovery Sites and Remnants.

- 3) Below the seepage point northeast coast
 - 4) Stockwater Dam
 - 5) Whare north-northwest coast
 - 6) Little manuka coves, 1&2
 - 7) Kanuka slips; Southern Beaches & Walkers Beach
 - 8) Bracken - scrub stands.
-

Type C: Gully Systems

- 9) Ward Homestead
 - 10) Stock water dam gullies
 - 11& 12) Walkers Beach gullies
 - 13, 14 & 15) Southern Beaches gullies
-

8.3.2 Nuclei creation

Nuclei should be made up of equal proportions of woody forest species selected from the appropriate reference states. Ideally speaking, rare, threatened and common species should be given equal proportional representation to allow the filtering forces in nature to select the composition best suited to the island. Obtaining equal proportions of all seedlings may prove impractical owing to the scarcity of some and the expense of others. Furthermore on the northern aspects it would be advisable to avoid planting obviously drought and salt sensitive species which are more suited to conditions in the moister southern side of the island, such as: Kahikatea (*Dacrycarpus dacrydioides*), wineberry (*Aristolia serrata*), tree fuchsia (*Fuchsia excorticata*), lemonwood (*Pittosporum eugenoides*), peppertree (*Pseudowintera colorata*) and sevenfinger (*Schefflera digitata*). With the possibility of the near total eradication of rabbits, the only browsing mammal on Quail Island, there is potential to provide a refuge for threatened and rare plants.

Experience from Tiritiri Matangi Island and Motutapu Island has shown that given appropriate conditions most forest species will survive once planted directly into grassland. It is assumed that the same will be true for local conditions. If this proves not to be the case the species composition of nuclei plantings will be revised and sensitive species can be added to the maturing nuclei when conditions become more favourable within the nuclei.

Owing to the composition of the reference states fast growing nurse species are as much a part of the nuclei as they are of the matrix. These will provide added shelter for sensitive slower growing species. It is expected that with their random integration, a partial cover could be attained in 2-5 years. The slower growing canopy trees will coalesce in an estimated 5-7 years.

Table 8.3 General Species Lists for Nuclei Plantings

Canopy species

Dacrycarpus dacrydioides Kahikatea

Prumnopitys ferruginea Miro (R.V.)

Podocarpus totara Totara

P.taxifolia Matai

Sub canopy species

Alectryon excelsus Titoki

Coprosma lucida Karamu

Cordyline australis Cabbage Tree

Dodonaea viscosa Akeake

Hedycarya arborea Porokaiwhiri

Hoheria sexstylosa Lacebark (R)

Lophomyrtus obcordata Rohutu

Melicytus ramiflorus Mahoe

Myrsine australis Mapou

Pennantia corymbosa Kaikomako

Pittosporum tenuifolium Kohuhu

Pseudopanax arboreus Five finger

P.ferox Fierce lancewood

Schefflera digitata Seven finger

Carpodetus serrata Putaputaweta

Aristotelia serrata Wineberry

C.robusta Karamu

Coriaria arborea Tree Tutu

Griselina litoralis Broadleaf

Hoheria angustifolia Lacebark

Leptospermum scoparium Manuka

Kunzea ericoides Kanuka

Myoporum laetum Ngaio

Olearia paniculata Akiraho

Pittosporum eugenoides Lemonwood

Plagianthus regius Lowland ribbonwood

P.crassifolia Horoeaka

Rhopalostylis sapida Nikau

Sophora microphylla Kowhai

Third tier

Coprosma areolata

Coprosma.crassifolia

Coprosma rhamnoides

Coprosma rotundifolia

Corokia cotoneaster

Fuchsia excortica x perscandens

H.strictissima Koromiko (R.End)

Helichrysum lanceolatum Niniao

Macropiper excelsum Kawakawa

Myrsine divaricatus

Olearia fragrantissima (R)

Solanum laciniatum Poroporo

Sophora microphylla Kowhai

Teucrium parvifolium (R)

Coprosma lineafolia

Coprosmapropinqua Mingimingi

Coprosma rigida

Coprosma virescens

Discaria toumatou

Hebe salicifolia Koromiko

Hebe lavaudiana (R.End)

Lophomyrtus obcordata Rohutu

Melicope simplex Poataniwha

Neomyrtus pedunculata (R)

Pseudowintera colorata Horopito

Sophora prostrata

Streblus heterophyllus Turepo

R.V = Regionally Vulnerable Species, R.E = Regionally

Endangered Species, R.End = Regionally Endemic species (Wilson, 1992a)

8.3.3 Matrix Creation

The matrix species lists are comprised of early colonising forest edge specialists. This species mix also characterises treeland and shrubland reference site species. Of the 43 species that make up the matrix, 25 have also been placed in the nuclei (ie 58%). In other words the nuclei is comprised of 42% (25/60) of species that are able to survive both in forest and forest in disturbance conditions. It is estimated that a canopy should be formed in 2-5 years. Matrix and gorse and broom canopies may merge to form a single cover in approximately a decade. From the rate of the development of forest using MIM strategy, it is estimated that forest will occupy the island in approximately 20-30 years. This gives a total of 30-40 years from time of initiation to attainment of a contemporary mixed matai /broadleaf forest. Of the matrix plantings that descend toward the sea, the concentration of salt tolerant species should be increased. This will help to ensure planting success and minimise losses (Table 8.5).

Table 8.4 General Matrix Species

<i>Coprosma propinqua</i> Mingimingi	<i>C. crassifolia</i>
<i>C. virescens</i>	<i>C. robusta</i> Karamu
<i>Corokia cotoneaster</i>	<i>Cordyline australis</i> Cabbage tree
<i>Carmichaelia "robusta"</i>	<i>Discaria toumatou</i> Matagouri
<i>Fuchsia perscandens</i>	<i>Hebe salicifolia</i> Koromiko
<i>H. strictissima</i> (R.End)	<i>Helichrysum lanceolotum</i>
<i>Hoheria angustifolia</i> Lacebark	<i>Macropiper excelsum</i> Kawakawa
<i>Melicytus ramiflorus</i> Mahoe	<i>Myrsine australis</i> Red matipo
<i>Pennantia corymbosa</i> Kaikomako	<i>Podocarpus totara</i> Totara
<i>Pseudopanax ferox</i>	<i>Pittosporum tenuifolium</i> Kohuhu
<i>Pittosporum obcordatum</i> (loc. ext)	<i>Plagianthus regius</i> Ribbonwood
<i>Solanum laciniatum</i> Poroporo	<i>Sophora prostrata</i> Dwarf kowhai
<i>Sophora microphylla</i> Kowhai	<i>Streblus heterophyllus</i> Turepo

R.V = Regionally Vulnerable Species, R.E = Regionally Endangered Species, R.End = Regionally Endemic species
 Loc.Ext.=Locally Extinct (Wilson, 1992a)

Table 8.5 Salt tolerant matrix species

<i>Carmichaelia arborea</i>	<i>C. kirkii</i> (coastal broom) (R.V.)
<i>Cassinia leptophylla</i> ,	<i>Coprosma lucida</i>
<i>Corynocarpus laevigatus</i> ,	<i>Dodonaea viscosa</i>
<i>Griselinia littoralis</i>	<i>Kunzea ericoides</i>
<i>Leptospermum scoparium</i>	<i>Myoporum laetum</i>
<i>Olearia paniculata</i>	<i>Phormium tenax</i>
<i>Plagianthus divaricatus</i>	<i>P.divaricatus x regius</i>
<i>Muehlenbeckia astonii</i>	<i>M.complexa</i>
<i>M.ephedriodes</i> (R.R)	

R.V = Regionally Vulnerable Species, R.E = Regionally Endangered Species, R.End = Regionally Endemic species

Loc.Ext.=Locally Extinct (Wilson, 1992a)

8.4 Planting out procedures

Planting in grassland

With the use of volunteer labour, seedlings should be grown in root trainers. They not only encourage healthy root development, they are easily transplanted (Porteus, 1993 pp.125,145). On Tiritiri Matangi Island they have proved to be the most convenient means for volunteers to handle and plant large numbers of seedlings.

Site preparation involves the removal of existing vegetation that creates competition for light, water and nutrients. It is vital for successful planting (Porteus, 1993 p.135). this may be done manually or chemically. The use of chemicals is not recommended. Not only is it unsustainable and dangerous it may prove to be a source of conflict between management and volunteers; this would be counterproductive to maximising public involvement.

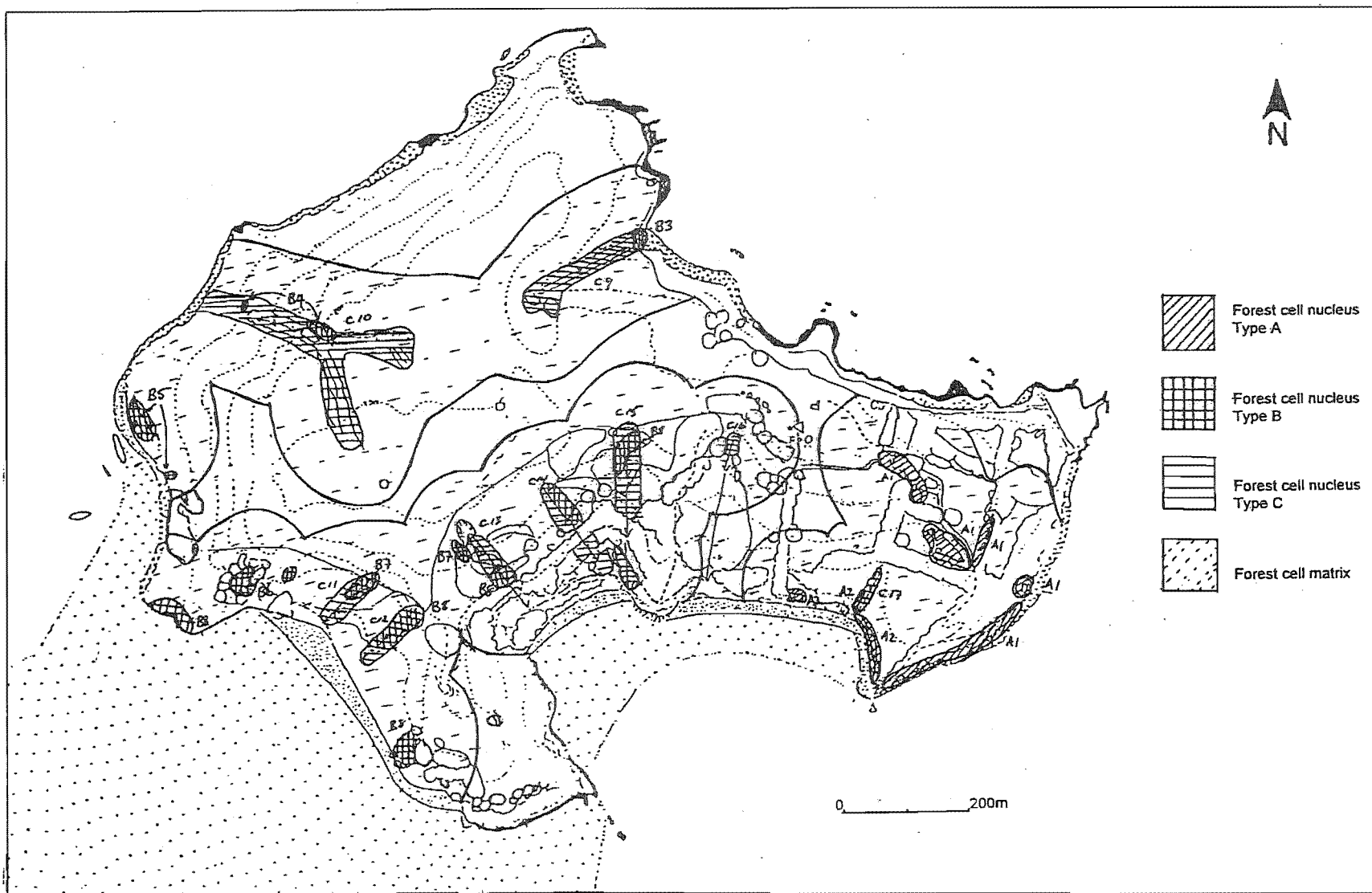


Figure 8.1 The "forest cell" approach for Quail Island. Map shows approximate dimensions and locations of cell nuclei and matrices (see Table 8.1 for details and c/ Figure 3.6).

As Quail Island has good levels of natural fertility, fertilisers may not be necessary. Seedlings should be planted out when they are no less than 30 cm tall. This should enable them to overtop grass in two growing seasons (Wilson, 1995). However seedling establishment is most successful when they are a metre or more in height (Timmins *et al.*, 1988). Attaining seedlings of such a size will be difficult if root trainers are used. They should be spaced 2m apart. Cluster planting is recommended over line planting (Norton, 1991; 1992; Porteus, 1993 p.141). Firstly they provide mutual protection and will eventually coalesce forming a single canopy cover. Furthermore frugivorous birds are attracted to groups of plants made up of several species rather than single plants (Porteus, 1993 p.141). Clusters may be spaced between 5 and 10 m apart.

8.5 Collection and Propagation

Propagation from seed is the most common method of seedling production. The nearest nurseries to Quail Island are at Governors Bay, Lyttelton and many of the required propagules may be obtained from the DoC Motukarara Nurseries at Taitapu. However despite the close proximity of these nurseries, it may be an advantage to establish a nursery on Quail Island so that haulage and transport costs are reduced.

Propagules should be collected firstly from plants growing on the island and other species derived from sources no more than a 5 km radius from Quail Island and ideally plants should be taken from open farmland from the same altitude (*cf* Timmins *et al.*, 1988). It is important that seeds are collected from different plants of the same species to avoid genetic homogeneity. Other potential propagule sources might be, roadsides, firebreaks, logging tracks, cleared fencelines and in areas of exotic forest (Porteus, 1994). The majority can however be found in the Protected Natural Areas and Recommended Areas for Protections of the Lyttelton Harbour Basin (see Wilson, 1992a). It is ill-advised to take seedlings and other propagules from reserved land. Collection from reserves is usually forbidden but permission can be sought from the DoC. Often rare and threatened species are found outside the island's bioclimatic zone.

However given the opportunity of developing a browser free environment establishing such species *ex situ* (despite its disadvantages) should not be missed.

8.6.0 Post-planting maintenance

The following is a brief list of essential tasks that will need to be considered after woody species have been planted. In order to conserve moisture, mulching is recommended. It is essential that the planted seedlings are released from competing the grass sward, and this should continue just until plants are above ungrazed grass height (Wilson and Wright, 1995). Watering seedlings is not recommended (Porteus, 1993; Wilson, 1995). The need for watering can be avoided by a well thought out planting strategy. That is planting in the late autumn and winter. Planting should occur before a wet spell and on overcast days (Porteus, 1993). Nevertheless seedling losses are to be expected in a drought year (Meurk, 1994).

8.6.1 Planting in shrubland

Forest cell Type B entails the enhancement of natural forest recovery sites with pre-colonial seedlings (Table 8.2, Figure 8.1). Under planting usually requires the creation of canopy gaps for seedlings. In the case of forest cell nuclei all species seedlings should be planted in appropriately sized clusters into light gaps.

8.6.2 Planting in Scrubland

Owing to the DoC control, little gorse is on Quail Island. However if it was allowed to spread it may provide a rapid nurse canopy which can be enhanced. Broom stands are found in two pockets on the south west coast (Figure 3.6). Broom has two advantages over gorse as a nurse crop: firstly it lacks thorns is consequently easy to work with,

secondly it will start to decline after 10-15 years while gorse will persist for 30-40 years before declining. Techniques for planting beneath broom are the same as for gorse. Full description of techniques is beyond the scope of this thesis, for good descriptions refer to Porteus (1993). Bracken in the Mt Herbert region operates more readily as a nurse crop than in the North Island (eg Tiritiri Matangi Island). Bracken will persist for up to 7 years before declining. It is advisable to clear light wells for pre-colonial seedlings (refer to Porteus, 1993 for details).

8.6.3 Planting under post-colonial plantation

It is known that *Pinus radiata*, eucalypts (Porteus, 1993 p102), willows (Caroline Pratt, pers com) and macrocarpa (pers obs) act as nurse canopies, however there is no information on the use of oaks and sycamores. With the proper site treatment, such as the cutting of light wells, these canopies may provide ideal settings for shade tolerant forest cell nucleus species (refer to Porteus, 1993 for details).

8.7 Planting trials

Planting trials in restoration projects are strongly recommended (Timmins *et al.*, 1988b). They are particularly important to avoid resource losses which occur most frequently during the first two years of planting (Norton, 1991). It is important to find the best combination of techniques to match local conditions and the species involved to maximise resources and minimise losses. The results should be fed back into the management system for review. This will ultimately refine the restoration process, the success of which will be determined by long term monitoring as described in Chapter 9. The most important initial indicators of success would be the rate of plant survival and the rate of plant growth. Plant survival tests the success of the planting strategy, the treatment of seedlings and the suitability of planting conditions. Growth rate measured as height at the end of the first growing season in comparison to the height of the grass

sward could be predictive of long term survival (Timmins *et al*, 1988b). These measures should be taken in relation to the following variables of interest.

8.7.1 Variables of interest

i) Site variability, ii) Appropriate plant species, iii) Site preparation iv) Planting methods and v) Post-planting care.

Site variability and appropriate plant species. Although every effort has been made to ensure that seedlings are planted in optimum sites, the success of establishment is likely to depend on the severity of the summer drought (*cf* Meurk, 1993). That is, suitability of sites will vary from year to year and from species to species. Owing to the natural range of tolerances, establishment of the full range of species in the forest cells may take a number of seasons to achieve. The monitoring of the filter process cannot be commenced until the full complement of species are present. Constant failure of certain species over a wide range of moisture conditions should lead to it being eliminated from the species lists, in this way the lists will be gradually refined.

A scaled down version of the planting procedure should be carried out involving a few representative species of a range of tolerances. Plots could be set up in representative forest cell sites; such as the Quarantine Paddocks (L/U#3), South West Bay (L/U#9) Ward House site (L/U#6) and Stockwater Dam (L/U#6) (Table 8.2). Plots should also be set up on the more exposed parts of the Plateau (L/U#6). Such plots will test the assumption that rates of survival and growth are better on southern aspects than on the moisture deficient northern and exposed aspects. It would also be informative to set up plots on comparable sites such as the northern tip of Mansons Peninsula and at Rapaki. Results would illustrate the effect of Quail Island's location and local conditions. Space does not permit further details of experimental design, this is reserved for a separate study.

A variety of techniques for site preparation, planting methods and post-planting care are available and it would be advisable to trial them in relation to site conditions and species. The objective should be to find the most effective and economic means to get a maximum survival and growth rates.

8.8 Non-woody species

Once forest cover is firmly established ground cover and climber restoration should be commenced. Large plantings of these species is considered unnecessary because they are able to mature and spread rapidly throughout the nuclei. Forest ground ferns and herbs can only establish once there is sufficient canopy to shade out the competing grass sward. However ground cover may be established in existing sites with an already developed canopy. Such sites are can be found within the 1983 revegetation planting sites and the natural forest recovery sites (Table 8.1). Species lists for planting into the aforementioned areas are listed in Table 8.5. Forest climbers should also be considered (Table 8.5) for re-introduction once the forest has established itself. The introduction of climbers at an early stage may impede growth and slow down the vital process of canopy development. Non-forest communities such as coastal cliff and beach communities should also be re-established; species considered appropriate for these sites are listed in Table 8.6.

Table 8.6 Non-woody ground plants for forest and scrub

Ferns

Adiantum fulvum Maiden hair fern (Loc.ext)

A.hookerianum

Asplenium richardii,

A.flabellifolium

Botrychium biforme Cut leaved parsley fern (R.R)

Hypolepis distans (Loc.ext)

H.peltatum (R.R)

H.rarum (R.R)

Rumohra hispida Leathery shield fern(R.R)

Herbs

Anogramma leptophylla (R.R)

Astelia fragrans Bush flax

Acaena juvenca

Arthropodium candium

Cardamine debilis

Corybas orbiculatus A spider orchid (R.R)

Clematis marata (R.V)

Dianella nigra (R.V.)

Gastrodia cunninghamii (R.V)

G.sesamoides Black orchid (R.V)

Lagenifera strangulata

Libertia ixiodes (R.R)

Grasses and Sedges

Poa mathewsii

Uncinia leptostachya

Carex solandri

C.raoullii

Uncinia sp (R.R).

U. banksii (R.R)

Climbers

Calystegia tugurioum

Clematis afoliata

C.foetida

Meulenbeckia australis

M.complexa

Parsonia heterophylla the native jasmine

P.capsularis

Passiflora tetrandranative passion vine.

Ripogonum scandens

Rubus schidelioides

R.squarrosus

Tetrapathaea tetrandra

R.V = Regionally Vulnerable Species, R.E = Regionally Endangered Species, R.End = Regionally Endemic species

Loc.Ext.=Locally Extinct (Wilson, 1992a)

Table 8.7 Non-forest communities of cliffs and beaches

Ferns

Anemanthele lessoniana (R..R)

Asplenium trichomanes (R..R).

Rumohora adiantiformis (Leathery shield fern)(R.V).

Grasses

Carex appressa (R.V)

Cortaderia richardii Toetoe

Desmoschoenus spiralis Pingao (R.V)

Elymus solandri Blue grass

Festuca Banks Peninsula blue tussock (Loc.End)

Hierochloa redolens, Holygrass

Lachnagrostis pilosa Windgrass

Lepidium oleraceum Cooks scurvy grass/Nau (Loc ext)

Luzula banksianiana Wood rush

Microlaena polynoda Rice grass (R.R)

Microlaena stipioides

Puccinellia stricta Saltgrass

Taraxacum magellanicum Native dandelion(Loc. ext)

Trisetum sp. 'slender'(R.R)

Herbs

Apium prostratum, native celery

Dysphysma australis Iceplant

Einadia allanii

Eryngium vesiculosum (R.R)

Gingidia montana Native ginger

Isolepis nodosa Club rush

Linum monogynum Rauhuia(R.R)

Myosotis australis var. *lytteltonensis* Forget-me-not (R.V)

Myosotis pygmaea var. *drucei* Dwarf forget-me-not (R.R)

Pentachondra pumila Dwarf heath (R.R)

Pratia perpusilla, Panakenake (R.R)

Senecio glaucophyllus Shore groundsel

Salicornia australis

Sarcocornia quinqueflora

Spergularia media Ssea spurrey

Thelymitra decora Sun orchid(R.R)

Libertia ixiodes Native iris

Tetragonia trigyna Native spinach or kokihi

Thelymitra longifolia White sunorchid(R.R)

R.V = Regionally Vulnerable Species, R.E = Regionally Endangered Species, R.End = Regionally Endemic species
Loc.Ext.=Locally Extinct (Wilson, 1992a)

8.9 Translocation of pre-colonial fauna

According to Towns *et al.* (1990) there are no land birds on the mainland of New Zealand unable to withstand minor predator pressure. The 33 known bird species which could not withstand interference by Pacific rats are now extinct and it is important now to meet the requirements of the remaining species. Owing to budgetary limitations, the Department of Conservation is unable to eliminate predators totally, but it is possible to maintain them at low levels. Although no mammalian predation is preferable, a small number of predators may allow certain species to adapt behaviourally to them, thus improving their chances of survival.

The following species were drawn from the fauna reference state species lists (Chapter 4). They were selected because they were known to be present in the vicinity of Quail Island. They are adapted to shrubland and second growth forest and they are considered appropriate for translocation to Quail Island once a partial canopy and full canopy is attained, that is after approximately 10-15 years and 20-25 respectively from the first year of planting.

8.9.1 Birds suitable for transitional forest vegetation

The easiest species to translocate to Quail Island will probably be the following: the fernbird (*Bowdleria punctatus*), rifleman (*Acanthisitta chloris*) and brown creeper (*Mohua novaeseelandiae*). They are all able to live in transitional forest habitat, such as brackenland and scrublands in the case of the fernbird, manuka and kanuka heath, in the case of the brown creeper and the rifleman. They were once extremely common in the Lyttelton Harbour Basin (Potts, 1884) but have all disappeared due to habitat destruction (Wilson, 1992; Falla *et al.*, 1979; Bell, 1990). The rifleman and brown creeper are able to live in contemporary conifer forests (Falla *et al.*, 1979 p.192, 178, pers obs) and may be able to make use of the amenity and shelter plantings on Quail Island. Translocation to Quail Island could occur after a canopy is established in 10 -15

years (Table 8.8).

The brown creeper is the most robust of all the potential species for release. It nests well above the ground and it is consequently the least at risk from predation. On the other hand the fernbird nests close to the ground and is a weak flier (Falla *et al*, 1979 p.190; Best, 1979) while the rifleman is a hole nester and vulnerable to attack from mustelids. It would be prudent to conduct experimental releases with the brown creeper to gauge the potential success of others.

The red-crowned kakariki was also a very common bird in the vicinity of the island (Potts, 1884), but was subject to heavy control measures when it was found to be an agricultural pest (Falla *et al*, 1979 p.163). It is well adapted to transitional vegetation (Taylor, 1985; Atkinson and Millener, 1990) and could be released at a similar time to the aforementioned after trials and establishment of predator resistant nest boxes. Currently individuals are being reared for release into the wild at Orana Park, on the outskirts of Christchurch. This may well form a convenient gene pool for Quail Island releases.

8.9.2 Birds of second and old growth forest

The yellowhead (Potts, 1882), robin (Fleming, 1946) and tomtit (Wilson, 1992a) were all common in the island's vicinity and their loss is caused principally through habitat destruction. The yellowhead, the robin and to a lesser degree the tomtit are better adapted to mature forest (Flack, 1976; Falla *et al*, 1979 p.188; Atkinson and Millener, 1990) and translocation should occur later, after 20-25 years. In regards to the yellowhead, Elliot (1990) showed that in productive forests the fecundity of this bird was sufficient to offset predation from stoats. Quail Island has a mild climate and semi-fertile soils; if forest was restored under these conditions it is likely to be productive. In such a habitat the yellowhead may have a chance of survival. There is little competition between these species owing to stratification of feeding levels in the forest,

feeding methods and selection of food. These species will join the resident fantail, greywarbler and shining cuckoo making a near full restoration of the arboreal insectivore guild.

The tui was a very common sight on Banks Peninsula and around the Port Hills during the colonial period and up until the mid 1900s. Today there is only one remaining bird in the Banks Peninsula Ecological Region, now found in the vicinity of Akaroa (Wilson, 1992a; Hugh Wilson, pers com). It remains unclear why this species has been unable to survive, although it is probably due to a combination of habitat loss, disease, possible harassment from the white backed magpie (Hugh Wilson, pers com) and/or competition for nectar food sources from the silvereye (*cf* Brockie, 1990). Once a full canopy is achieved on Quail Island the tui can be re-introduced. If successful it will join the occasional bellbird to completely restore the South Island nectarivore guild. Competition between these two species is avoided by use of different nectar sources and a staggering of preference for insects and fruits. However with the presence of the silvereye and casual honeyeaters such as the starling, it is likely that there will be some competition.

8.9.3 Coastal Species

Special attention has been given to the three coastal species of, white flippered penguin or korora (*Eudyputa minor albosignala*), titi (*Puffinus griseus*) and the fairy prion (*Pachyptila minor*) for the following reasons. Firstly they are not dependent on forest cover and secondly they have special cultural significance to the *Tangata Whenua*. Owing to the popularity and appeal of penguins to the public (Ian MacLean, pers com) it may be an advantage to use the korora as one of the restoration project's flagship species

Korora/White Flippered Penguin (*Eudypota minor albosignala*)

Potts (1882 p.213) reports the korora or the white flippered penguin (*Eudypota minor albosignala*) as common throughout the Port Cooper (Lyttelton Harbour) area. Quail Island at one stage supported a breeding population but this was destroyed presumably through predation from stoats (Department of Lands and Survey, 1983).

The best sites to establish a penguin rookery on Quail Island would be on the northern coasts of the island where there is access to the plateau, rabbit burrow sites¹ and there is direct access to the sea. Re-establishment of a breeding colony works on the premise that these penguins will usually return to their fledging site to breed (Waas, 1988; Chris Challies, pers com). Penguin chicks should be translocated to suitable nesting sites on the island before they are fledged. At this stage they are independent of their parents and will tolerate displacement. After fledging they will leave their rookery for a two to four year period before returning to breed. Of the chicks fledged between 40-50% will return to the same site to breed. The balance will go to other colonies in the vicinity.

Titi/ Sooty Shearwater (*Puffinus griseus*) and Titi wainui / Fairy Prion (*Pachyptila minor*).

The Maori at Rapaki record titi in the Whakaraupo region and notably on Quail Island. Titi was an important resource and they still maintain hunting rights over this bird. It is the desire of the Rapaki Ranunga that a population be restored to the island for cultural harvest (Swindells, per com). Before the forests were cleared for agriculture the sooty shearwater and the fairy prion/titi wainui bred on most headlands around Banks Peninsula. Now the fairy prion is restricted to a few islets but small colonies of sooties

¹ Korora will often take over deserted burrows of prions or rabbits instead of digging their own. The number of korora is thought to be limited by the availability of burrows (Taylor, 1967). Artificial burrows have shown to be successful on Tiritiri Island. Nest boxes were made by Kiwi Conservation Clubs for Tiritiri Island which provided good opportunities for advocacy.

exist on steep slopes out of reach of stock.(Stead,1927;Turbott,1969). Stead (1927) believes their demise was due principally to predation by stoats.

Re-establishing colonies of both species would follow a similar strategy of the white flippered penguin, that is of translocating pre-fledged chicks to vacant burrows after they have been deserted by parents. Alternatively it is possible to attract petrels to new colonies by playing tape recorded calls (Tennyson,1990). This technique will be trialed on Mana Island (Miskelly,1995). The re-establishment of these two birds may prove more difficult than the korora. Petrels are nocturnal birds that are particularly attracted to artificial light. This has been known to disorientate and generally disturb them. Furthermore since the population of titi around Canterbury is quite low, it is feared that the attempted translocation may harm the existing colony (Chris Challies, pers com).

Table 8.8 Possible suggestions for reintroduction of avifauna after a woody canopy is established. Potential release dates were derived from estimations from a start date of 1997 (Table 8.8). Scrub and shrub canopy could be attained in 10-15 years and a low forest canopy could be achieved in 20-25 years. Scrub birds should be reintroduced after 10-15 years and those species suited to low forest reintroduced after 20-25 years.

Species	Potential Release date
Fernbird (<i>Bowdleria punctatus</i>)	2007-2012
Rifleman (<i>Acanthisitta chloris</i>)	2007-2012
Brown creeper (<i>Mohua novaeseelandiae</i>)	2007-2012
Red crowned kakariki (<i>Cyanoramphus novaezelandiae</i>)	2007-2012
South Island robin (<i>Petroica australis</i>)	2017-2022
Tui (<i>Prosthemadora novaeseelandiae</i>)	2017-2022
South Island tomtit (<i>Petroica macrocephala</i>).	2017-2022
Yellowhead (<i>M. ocrecephala</i>) ?	2017-2022
White Flippered Penguin/korora (<i>Eudyptes minor albosignala</i>).	1998-99

8.10 Reptiles

The endemic jewelled gecko (*Heteropholis gemmeus*) and the forest gecko (*Hoplodactylus granulatus*) favour a forest habitat. Introduction of these species should not occur until a suitable canopy is attained to provide food reserves and cover from predators. The common gecko (*Hoplodactylus maculatus*) and spotted skink (*Oligosoma lineoocellatum*) are at home in scrub as well as in forest and could be released after a canopy closure occurs in the forest cells. These species will join the common gecko (*Hoplodactylus pacificus*) and the brown skink (*Oligosoma zelandica*) resident on the island, both are readily transferable to forest.

Table 8.9 Possible suggestions for translocation of herpetofauna. Potential release dates calculated in the same way as for Table 8.8

Species	Potential Release date
Common gecko (<i>Hoplodactylus maculatus</i>)	2007-2012
Spotted skink (<i>Oligosoma lineoocellatum</i>)	2007-2012
Jewelled gecko (<i>Heteropholis gemmeus</i>)	2017-2022
Forest gecko (<i>Hoplodactylus granulatus</i>)	2017-2022

8.11 Conclusions

In this chapter I presented the "forest cell approach" as a medium management strategy that mimics and accelerates natural forest recovery patterns occurring on Banks Peninsula. Seedlings should be planted in sites of moisture accumulation such as south facing gullies, slopes and beneath existing scrub and second growth forest. Within the forest cell the zone of greatest moisture accumulation is planted with a selection of old

growth forest species called the forest nuclei. This is surrounded by a matrix of forest edge species, forest colonisers and scrubland species. It is expected that the nucleus will spread out into the matrix and the matrix into the grassland, finally coalescing with other planted forest cells. Species lists have been provided for both woody and non-woody species.

Finally from the species lists of avifauna, nine species of bird were selected for translocation to Quail Island at different stages during the forest restoration process. Attempts to translocate white flippered penguin, muttonbird and fairy prion can commence once rabbits have been cleared and a system for predator control is developed. Following the establishment of a low forest canopy after 10-15 years, browncreeper, rifleman, robin and red crowned parakeet could be released. At a later stage (after 20-25years) older growth species such as tui and yellowhead may be considered.

Chapter 9: Monitoring

9.0 Introduction

Monitoring is essential to determine progress and success of restoration projects (Norton, 1992). It is necessary to set appropriate success criteria and to have a suitable programme to monitor them. For the purposes of this concept plan, initial success would be achieved when forest recovery processes have been reactivated, accelerated and enhanced with a predominance of pre-colonial species. This may be interpreted as the successful establishment of a canopy and the spread of forest cells into the island's grassland and scrubland, providing habitat for transitional forest avifauna and herpetofauna. The success in the long term would be achieved when a near complete cover of mature forest on Quail Island is attained and habitat provided for self maintaining populations of forest fauna.

It should be acknowledged that as both the antecedent vegetation and the outcome of the restoration process for Quail Island can only be estimated, monitoring the process of restoration effectively may be considered hypothesis testing (*cf.* Aronson *et al.*, 1993; Bradshaw, 1987; Jordan III, 1987). In this light the project becomes research through management.

The purpose of this chapter is to outline the criteria for determining progress and success of the restoration process. In section 9.1, changes in canopy cover and relative plant and vertebrate species abundances in relation to predicted vegetation changes are discussed. This project provides many opportunities to monitor a wider range of ecosystem changes and to test associated hypotheses. One way to approach this is through the monitoring of the ecosystem health described in section 9.4. As examined in Chapter 6, the role of the community will be an integral part of the restoration of Quail Island. Visitors will provide opportunities for conservation advocacy and education, as well as providing support through participative recreation. However it is essential that their

presence and activities are well managed to avoid the incursion of negative impacts. In Section 9.5 the principles for the development of a visitor impact monitoring programme is suggested. It was argued in Chapter 6 that participative recreation fits the current definitions of ecotourism. It was pointed out that sustainable development and nature conservation are natural products of this form of tourism. To this end, evidence of the practice of sustainable development and nature conservation can be regarded as criteria for success. A general framework for the development of these criteria for monitoring these factors is presented in section 9.6.

9.1.0 Monitoring the success of the forest cell approach

The primary concern of the stakeholders is likely to be two fold: the rate at which a forest canopy can be achieved over most of the island, followed by the changes in bird population diversity and abundance.

9.1.1 Monitoring canopy cover and relative species abundances

Surveys should involve the search for evidence that the forest cells are spreading into the grassland and that forest cell nuclei species are spreading into the forest cell matrices. In the longer term, it would be important to determine how well the forest cells and the internal clusters act as foci for propagules. Both these objectives can be achieved through the census all seedlings of woody plants (refer to Robinson and Handel, 1993 for an appropriate methodology). It is expected that canopy closure within cells will occur 2-7 years after planting (Chapter 8.2.1). Changes in canopy cover in relation to predicted vegetation changes can be determined through calculation of % cover. As the area of plantings is large it would be wise to monitor representative samples; for example belt transects that cover the full range of environmental conditions on Quail Island and the trial plots described in Chapter 8.6. The monitoring of growth and survival rates should be useful for determining success and progress and they

should be used in conjunction with cover and relative abundances.

9.2 Monitoring birds and reptiles

Owing to the appeal of birds to the public, the success of translocations to the island and changes in existing populations should be monitored closely. Changes in bird species relative abundance should be indicative of the progress of the restoration process. For example as forest develops on the island it is expected that kereru and bellbirds will be attracted to the island from neighbouring regions. Furthermore it is expected that numbers of post-colonial European species should decrease as grassland habitat is steadily reduced. Harrier hawks feed on the poisoned carcasses of rabbits and it is expected that this will result in some losses. It will be important to monitor their number before and after rabbit control. For a full discussion of the techniques for monitoring terrestrial birds see Hay *et al* (1988), Dawson (1981), Dawson and Bull (1975) and Harrison and Saunders (1981). For a discussion on the monitoring of sea birds refer to Darby (1989). All lizards should be monitored. For survey techniques see McIvor (1970), Newman and Towns (1985) and Patterson (1992).

9.3 Monitoring weeds and pests

Species that may interfere with the maximisation of pre-colonial biodiversity should be controlled where appropriate (Table 7.1). Monitoring of these should be carried out, the results will determine what control measures should be taken. The population status of mammals on Quail Island is unknown, it should be a priority to assess it and the effects it is likely to have on proposed restoration process. As the mustelid populations are probably dependant on rabbit numbers, it would be informative to monitor predator numbers before and after rabbit control programmes. It is important to know when predator numbers are sufficiently high to constitute a serious risk to the viability of forest and sea bird populations. For a full review of mammal monitoring techniques

refer to King (1989).

9.4 Monitoring ecosystem health

Increasing forest cover and biodiversity could be interpreted as an increase in the quality of the island's ecosystem, expressed in terms improvement in ecosystem health. Ecosystem health can be determined by the recovery of ecosystem structure, composition and function (Hobbs and Norton, 1996). The concept of ecosystem health is controversial, for a review of the arguments see, Bratton (1992), Karr (1992 and Ehrenfield (1992).

9.4.1 Benchmarks for Quail Island

Attributes should be selected from a "healthy" reference state to form an "ecological reference template" (Allen, 1994). These will define a range of ecosystem process states and structural variables. The pre-settlement reference state (Chapter 4.2.1) may constitute the theoretical ecosystem baseline. This should be used in conjunction with Northwest Bay, Tipparary, Ngaio Point and the Ahuriri Valley Bush described in Chapter 4.2.0. These four sites may be used together to form a mean baseline. This information could be combined with the same measures of Quail Island to yield a general index of similarity. It is also important to provide a control. A control might be an abandoned field in a similar setting to Quail Island; any of the headlands in Lyttelton Harbour would suffice for this. Comparisons of results between these sites will reveal the effectiveness of the planting and translocation strategy. It would be also interesting to make comparisons between the forest nuclei approach and minimum and intense management strategies. This would quickly determine the usefulness of this restoration technique.

"Vital Ecosystem Attributes"(VEAs) for ecosystem structure and function (Aronson *et*

al,1993) provide a starting point for assembling a set of parameters to be monitored (Hobbs and Norton, 1996). VEAs are defined by those authors as those attributes that can serve as indicators of ecosystem structure and function over a given stage of its development. It is well known that the development of forest soils is an important indicator of successful restoration (Norton,1992). To this end Aronson *et al* (1993) selected those attributes related to vegetation, soils and micro-organisms. The selected factors are easily quantified, providing good sources of comparison between different stages of the ecosystem change and also between other ecosystems. The attributes selected by Aronson *et al.* (1993) are often controversial and their monitoring provides several opportunities for research. Those VEAs considered to be of relevance to this project are described. It is acknowledged that many of the measures of vegetation changes overlap with both planting trial measures and immediate indicators of success and progress described earlier; this illustrates potential multiple uses of the data.

9.4.2 VEAs for ecosystem structure (after Aronson *et al.*, 1993)

i) Woody to herbaceous species richness and ii) annual species richness. Disturbance sites are often colonised by annual plants which give way to perennial ones. Herbaceous perennial species give way to woody species. These changes indicate the processes of old field succession and the effectiveness of the management approach.

iii) Total plant cover. The rate of the spread of forest cells measured through percentage canopy cover is an important measure of the success of the forest cell approach.

iv)Beta diversity and vi) Life form spectrum. Beta diversity refers to the amount of species turnover or replacement along an environmental gradient. Given the very strong influence of aspect over species diversity, this is a useful parameter for Quail Island Where southern sites have greater diversity and propensity for forest recovery than northern sites. The life form spectrum (Raunkiaer, 1934) declines with ecosystem degradation. The monitoring of these factor provides an opportunity to test the

hypothesis that beta diversity and life form spectrum declines with ecosystem degradation, while alpha diversity increases temporarily (Aronson *et al*, 1993)

vi) Microbial biomass and viii) soil biota diversity. Soil micro-organisms have a profound influence on terrestrial ecosystems. The presence of forest fungal species would be indicative of the development of a forest humus layer and of the development of a forest soil. Furthermore it is expected that as forest vegetation matures and develops, the quantity of nitrogen in the soil steadily decreases. Surveys of nitrogen fixing soil bacteria will reveal this developmental process. It is hypothesised that soil biota diversity declines with ecosystem degeneration.

9.4.3 VEAs for measuring ecosystem function (after Aronson *et al*, 1993)

i) Biomass productivity (kg biomass ha/yr). As an ecosystem matures the ratio of standing biomass to annual productivity will generally increase (Margalef, 1969). However there are some exceptions, such as when some disturbance sites are invaded by productive leguminous plants.

ii) Soil organic matter. There is a positive correlation in New Zealand soils between above ground plant mass and levels of organic matter. Measurements could include the depth of O horizon and quantity of dead organic material (Norton, 1994).

iii) Maximum available soil water reserves. Stored soil water reserves may have a strong impact on the amount of plant biomass and productivity. As ecosystems mature their capacity to retain moisture increases.

iv) Coefficient of rainfall efficiency. This indicates surface conditions and the absorption capacity of soils. This is a measure of the amount of rain water infiltration in the middle and deep layer of the soil. Degraded soils have a tendency to form a crust and prevent infiltration. With increased vegetation there should be greater infiltration

via root systems.

v) Rainwater use efficiency. This represents the relationships between above ground phytomass and annual rainfall and serves as an indicator of soils and ecosystem productivity.

vi) Length of water availability period. This facilitates the prediction of seasonality, duration and extent of plant growth.

vii) Nitrogen use efficiency. There is usually less nitrogen in forest soils than in grassland soils. It would therefore be expected that nitrogen content in soil would decrease with increasing canopy cover.

9.5 Monitoring visitor impacts

Participative recreation in restoration projects appears to have overcome the "classic impasse" of tourist site development (Chapter 6.2). For example the greater the number of volunteers, the greater the number of trees planted, resulting in an amelioration of the environment rather than a degradation. However this is contingent on a suitable management regime that respects resource carrying capacities and minimises negative visitor impacts. The main impacts of large number of visitors are likely to be disturbance of bird and plant populations after their re-establishment, along with the erosion of tracks and beaches. In other words the forces that restore the island may, if unmanaged, become the ones that degrade it.

The hope of stemming the threat of these impacts centres on the setting of adequate carrying capacities for the site, before the project's inception. Such levels can only be set through an understanding of the pertinent biophysical, social and managerial conditions. The Recreation Opportunity Spectrum (ROS) provides a framework to deduce and examine them (Delvin and O'Connor, 1988). Within this framework a set

of standards or the Limits of Acceptable Change (LAC) (Stankey and McCool, 1984 cited in Delvin and O'Connor, 1989) will have to be established (Delvin and O'Connor, 1989). This involves the establishment of a system of zones, environmental standards and a monitoring procedure to prevent the degradation of the conservation resource. LAC must be set in relation to the expected changes during the restoration process. ROS and LAC were designed to cover the full range of recreation environments and are applicable to a "Restoration Island" context of Quail Island. Table 9.1 lists the necessary steps that should be taken to formulate a management policy and standards to guide the management process.

Table 9.1 The ROS and LAC process (after Delvin and O'Connor, 1989).

ROS	LAC
Step 1: Estimation of demand opportunities on the ROS	Identify issues and concerns in an areas
Step 2: Assess potential recreation capabilities of an area	Define and describe opportunity classes in the area
Step 3: Identify current patterns of recreation in the area	Select key indicators of resource and social conditions in the area
Step 4: Using demand and capability data, determine opportunities to be maintained/altered	Inventory existing resource and social conditions in the area
Step 5: Integrate recommendations from above with those for users of other areas	Specify standards for key indicators of conditions in each opportunity class
Step 6: Develop series of alternative plans for resource allocations in the area	Identify alternative opportunity classes using results from Steps 1 and 4
Step 7: Develop management plans implementing option selected from Step 6	Identify management action required for implementation of each alternative from Step6
Step 8:	Evaluation/selection of preferred alternative with particular reference to results from Steps 2 and 4
Step 9:	Implement Step 7 action required, and monitoring changing conditions with indicators (Step 3) and standards (Step 5)

9.6 Ecotourism criteria for success

Sustainable development and environmental conservation are the expressions of ecotourism. When these are occurring the project can be said to have reached a certain level of success. Butler (1993) and Owen *et al* (1993) have developed working definitions of sustainable development in a tourism context to be used as touchstones or yardsticks. These may be used as criteria for the success of the restoration project. It should be noted that factors i), iv) and v) after Owen *et al*. (1993) and Butler's (1993) definition cannot be monitored until measureable criteria or standards have been developed. This is beyond the scope of this study and is a subject for future research.

Butler suggests that Sustainable Tourist Development could be taken as :

"Tourism which is developed and maintained in an area (community, environment) in such a manner and at such a scale that it remains viable over an indefinite period and does not degrade or alter the environment (human, physical) in which it exists to such a degree that it prohibits the successful development and well being of other activities and processes."

Owen *et al* (1993) offer a working definition in the form of five key principles:

i) *Tourism is a potent economic activity which brings tangible benefits to the host community as well as to the visitor; however, tourism is not a panacea and must form part of a balanced economy.*

ii) *The physical and cultural environments have intrinsic values which outweigh their values as tourism assets; their enjoyment by future generations and long term survival should not be prejudiced by short term considerations.* Environmental monitoring regime discussed above, can be used to measure the impacts of the tourist operations. These will help safeguard the limits of acceptable change.

iii) *The scale and the pace of tourism development should respect the character of the area. Value for money and a high quality tourist experience should be provided.* So that it does not compromise the conservation objectives, there should be a limit on the size that tourist ventures can grow on the island.

iv) *The goal of optimum long term economic benefit to the community as a whole should be pursued, rather than short term speculative gain for only a few.*

v) *Tourism development should be sensitive to the needs and aspirations of the host population. It should provide for local participation in decision making and employment of local people.*

9.7 Conclusions

It is proposed that restoration progress be monitored through the periodic measurement of ecosystem health. This may be determined through the monitoring of selected vital ecosystem attributes; those chosen relate to vegetation, soils and micro-organisms. The primary concern of the stakeholders is assumed to be two fold: the rate at which a forest canopy can be achieved over most of the island, followed by the changes in bird population diversity and abundance. Owing to the importance of the role of the public in this restoration project, special attention should be given to these issues. The steps needed to be taken to formulate a framework for the development of a policy and a set of standards to prevent environmental degradation are outlined in the form of the Recreation Opportunity Spectrum (ROS) and the Limits of Acceptable Change (LAC). The success of the project as an ecotourism or participative recreation destination could be determined by the attainment of sustainable tourist development and the practice of conservation.

It is important that the results from each phase of monitoring are used to revise management strategies to ensure the restoration goal can be achieved. It is vital that the management structure is flexible enough to allow this to happen.

Chapter 10: Summary and Conclusions

10.0 Introduction

The aim of this thesis was to formulate a set of principles for the ecological restoration of Quail Island. This entailed the development of the restoration vision, goal and process. The goal is formed from the restoration philosophy and vision, which are expressed practically through the restoration process.

As restoration ecology is still largely in its infancy (often with more exceptions to rules than rules), the development of these ideas required that, they be first clarified and that a suitable methodology to develop them be formulated. The creation of this concept plan required an examination and a reshaping of existing principles and an invention of others to fit the island's natural and cultural context. This involved a qualitative examination of a large number of aspects of the island's ecology and cultural environment and of existing projects. In many instances the investigations have led me to challenge the ideological basis for conservation practice in New Zealand and to suggest an alternative. In the following passages I have summarised the the main findings and recommendations. This begins with an overview of the main tenets of the restoration philosophy, followed by a statement of the restoration vision and goal. This is followed by a summary of the practical applications of these principles in the form of recommendations for the formation of an appropriate restoration process.

10.1 The restoration philosophy

The restoration philosophy is made up of five basic tenets, they are as follows:

i) Indigenusness is spatially and temporally contextual. This tenet leads to a rejection of the prevailing New Zealand conservation values system which is summarised as

"what is natural is indigenous, what is indigenous is old (pre-1840) and what is old is good". In this dissertation species present before 1840 are termed "pre-colonial" and those arriving after European settlement are referred to as "post-colonial" species. Together they form a contemporary hybrid biota.

ii) Through a postmodern argument, ecological restoration is reasoned to be an expression of compassion for the landscape.

iii) Community assembly is governed by environmental filters which select out functional groups of species from a pool of local biodiversity. The outcome of the selection process will be the community best adapted to prevailing environmental conditions.

iv) Although the Darwinian view of the genetic superiority of post-colonial species over pre-colonial species remains unsubstantiated, through compassion for the other, it is our duty to maximise the proportion of pre-colonial to post-colonial species in the contemporary ecosystem.

v) Given environmental changes, it is inappropriate to attempt to copy an antecedent and/or environmentally analogous forest ecosystems. Instead these ecosystems serve as reference states, from which a pool of ecologically appropriate species is drawn and supplanted on the island. It is believed that the prevailing environmental filters will sort out the final ecosystem composition, structure and function.

10.2 The Restoration vision

It is deduced that a (sub-humid) maritime-cool temperate, mixed broadleaf-podocarp forest, probably covered most of Quail Island in presettlement times. The island is edaphically and climatically comparable to the mainland. Within the semi-natural landscape context, the restored island has enormous potential to provide

"representative" habitat for some locally extinct forest and coastal species . Natural forest regeneration is occurring in isolated pockets on the island. There are a number of successional sequences that will lead a disturbed site to forest in the Lyttelton Harbour vicinity. It is now recognised that gorse, broom and elder play important roles in a common vegetational change sequence from grassland to mahoe dominated broadleaf forest. This sequence will occur on Quail Island given a cessation of the weed control activity by the Department of Conservation and the control of rabbit population.

10.3 The Restoration goal

To allow nature to determine the final forest structure and function, while ensuring that a predominantly pre-colonial species composition of plants and avi-fauna is achieved. The restoration process should be designed to accelerate and reinitiate pre-colonial forest recovery processes. Contemporary vegetation change sequences should be allowed to proceed with enhancement from pre-colonial elements. This should be achieved through a medium interference approach.

10.4 The Restoration Process

In order to transform the predominantly grassland native scrub ecosystem to a regenerating forest ecosystem will require some energy. There are number of natural constraints that need to be addressed to achieve this. The principal constraints to the success of the project are very high rabbit numbers and the presence of mammalian predators. With a concentrated eradication programme the rabbit population could be marginalised with the flow on effect of "crashing" the stoat and rat populations. From the point where the browsing influence is minimalised natural regeneration will take place as part of a long vegetational change sequence leading to matai-broadleaf forest. The acceleration and reinitiation of recovery processes could begin at this point. With water supplied from the mainland, the scarcity of natural water is no longer considered

to be a major constraint. Furthermore potential problems associated with water scarcity can be overcome with careful planning and management.

The restoration strategy is termed the "Forest Cell Approach." It is a medium interference approach based on the notion that communities are assembled through environmentally mediated filters. Integral to this are the processes of nucleation and patch dynamics in old field vegetation change which operate within the boundaries of these filters. "Forest cells" consist of a central nucleus of selected old growth forest species planted in appropriate clusters in sites of moisture accumulation, such as gullies, natural sites of recovery and around previously planted stands of natives within remaining shelter belts. The nucleus is surrounded by a matrix of forest edge and shrubland species. Through the processes of seed dispersal the nucleus will spread into the matrix and the matrix will colonise the grassland.

A low canopy forest could be established after 10-15 years. Local pre-colonial birds not resident on the island such as Bellbird and Kereru may well become resident or at least use it as a lowland component to their Port Hills and Mt Herbert ranges. Furthermore selected locally extinct bird and reptile species could be translocated to the island. As it will be difficult to keep the island predator free it is envisaged that the translocated bird community should be made of species that can resist some predation. These should be species that have (in other areas of the country and Banks Peninsula) stable populations, and one can assume they have reached an equilibrium with the exotic species. As Quail Island is semi-fertile, forest productivity should be relatively high. Under such conditions forest species should be more fecund and able to offset likely predation.

10.5 Community involvement

A scoping survey of visitors to the island revealed that the majority of all respondents supported the idea of ecologically restoring the island. This was usually stated with a

proviso that it did not interfere with their use of the popular southern beaches. The majority of the sample said it would appreciate and visit the island more frequently if it was restored. The majority said it would be prepared to give a donation or participate in the planting of trees.

Quail Island has a great deal of spiritual and historic value for the *Tangata Whenua*. It is the view of the elders of the Rapaki Runanga that the ecological restoration of Quail Island would be an expression of "giving something back to the land" and for this reason they support the restoration concept.

It is envisaged that a charitable trust involving the Rapaki Runanga, the Department of Conservation, representatives of conservation and other community groups should be established. Their role would be to raise funds for the restoration while both managing and overseeing the restoration. Funding may come from donations of money, time and resources from the community. It may also come from concessionaries based on the island. It is recommended that the conservation and development aspirations of the trust can be best achieved and enhanced through the development of Quail Island as a Biosphere Reserve.

10.6 Conclusion

The purpose of the proposed restoration project is not recreate an antecedent pristine state. It is to enhance the diversity of, and to extend the range of the forest/bird systems of the Lyttelton Harbour Basin. This project aims to allow the generation of new processes from old and new components to save what is left of some of New Zealand's pre-settlement biodiversity. The outcome of the restoration process will be a hybrid native/exotic forest or a "Contemporary Forest Ecosystem". That is it will not be representative of the past state but a modern variant of it.

The use of the medium interference strategy could be criticised as a "cop out", that is

giving up the fight against exotics and thus playing into the hands of the enemy. Instead, I believe, it represents an attempt to do the best we can within the confines of limited resources, technology and knowledge. Furthermore, at the core of this work is a wish to shift the conservation movement away from an irrational contempt of the semi-natural world to an acceptance of the role humanity can play in ecosystem dynamics. Not unlike other restoration projects, this can be thought of as a small step towards the abolition of the duality that exists between western society and nature.

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Appendices

Appendix 1

Temperature estimations for Quail Island and Mt. Herbert

Estimated mean annual temperature using Cherry's(1987) climate model for Banks Peninsula :
 $T_{est} = 11.8 - 0.005z + TAs + Tsh + TSea$

Where, T_{est} = the site mean temperature on °C, z = elevation in m, z_c = the distance from the coast in km, $TAs = +0.5^{\circ}C$ for north aspect, $TAs = -1.0$ for south aspect. Due to shadowing in valleys, temperature for northern aspects should be reduced by $0.2^{\circ}C$ and reduced by $0.4^{\circ}C$ for southern aspects (Cherry,1987).

Predicted temperature normals for Quail Island and Mt. Herbert using model developed by Norton (1985).

Quail Island (Q.I.)	Mt. Herbert (M.H.)
Latitude (L) $37^{\circ} 36' = 3760$	$43^{\circ} 41' = 4368$
Altitude (A) = 86 m asl	920m asl
Distance from the sea (D) = 1.4km	5.0 km
Q. I. Summer max: $36.51 - 0.00369L - 0.00612A + 0.03873D$	= $22.7 \pm 1.1^{\circ}C$
M.H. " "	= $14.95 \pm 0.9^{\circ}C$
Q.I. Winter min: $27.66 - 0.00565L - 0.00297A - 0.03325D$	= $6.2 \pm 1.4^{\circ}C$
M.H. " "	= $-5.0 \pm 1.4^{\circ}C$
Q.I Mean annual temp: $31.40 - 0.00450L - 0.00499A - 0.00187D$	= $14.07 \pm 0.5^{\circ}C$
M.H. " " "	= $11.73 \pm 0.5^{\circ}C$

Appendix 2

Checklist of plants for Quail Island (adapted from Molloy,1978).

TREES AND SHRUBS

a) NATURAL

<i>Cordyline australis</i>	- cabbage tree
<i>Coproma robusta</i>	- karamu
<i>C. propinqua</i>	- coprosma
<i>C. crassifolia</i>	- coprosma
<i>C. virescens</i>	- coprosma
<i>Carmichaelia robusta</i>	- native broom
<i>Plagianthus divaricatus</i>	- coastal ribbonwood
<i>Olearia paniculata</i>	- akeake
<i>Discaria toumatou</i>	- matagouri
<i>Hebe strictissima</i>	- hebe
<i>Kunzea ericoides</i>	- kanuka
<i>Leptospermum scoparium</i>	- manuka
<i>Pittosporum tenuifolium</i>	- matipo
<i>Melicytus ramiflorus</i>	- mahoe
<i>Myoporum laetum</i>	- ngaio
<i>Solanum laciniatum</i>	
<i>Griselinia littoralis</i>	- broadleaf
<i>Urtica ferox</i>	- tree nettle

b) PLANTED OR ADVENTIVE

<i>Sophora microphylla</i>	- common kowhai
<i>Corynocarpus laevigata</i>	- karaka
<i>Olearia traversii</i>	- Chatham Is endemic
<i>Pittosporum ralphii</i>	- N. Island species
<i>P. crassifolium</i>	- N. Island, karo
<i>Eucalyptus</i> sp.	- gum
<i>Pinus radiata</i>	- radiata pine
<i>P. nigra</i>	
<i>Pinus</i> sp.	
<i>Cupressus macrocarpa</i>	- macrocarpa
<i>Crataegus monogyna</i>	- hawthorn
<i>Sambucus nigra</i>	- elder
<i>Rosa rubiginosa</i>	- sweet brier
<i>Ribes uva-crispa</i>	- gooseberry
<i>R. glutinosum</i>	- flowering currant
<i>Ulex europaeus</i>	- gorse

<i>Erica</i> sp.	- heath
<i>Lycium ferocissimum</i>	- boxthorn
<i>Cytisus scoparius</i>	- broom
<i>Ilex aquifolium</i>	- holly
<i>Quercus ilex</i>	- holm oak
<i>Quercus</i> sp.	
<i>Berberis glaucocarpa</i>	- barberry
<i>Acer pseudoplatanus</i>	- sycamore
<i>Sedum praealtum</i>	- shrubby stone crop
<i>Chrysanthemoides monilifera</i>	- bone seed

WOODY CLIMBERS

<i>Muehlenbeckia australis</i>	- pohue
<i>M. complexa</i>	- pohue
<i>Rubus schmidelioides</i>	- lawyer
<i>R. squarrosus</i>	- lawyer
<i>Calystegia urguirorum</i>	- New Zealand birdweed

GRASSES AND GRASSLIKE PLANTS

a) NATURAL

<i>Poa caespitosa</i>	- silver tussock
<i>Agropyron scabrum</i>	- wheat grass
<i>Dichelachne crinita</i>	- plume grass
<i>Notodanthonia clavata</i>	- danthonia
<i>Juncus gregiflorus</i>	- rush
<i>Luzula banksiana</i>	- woodrush
<i>Phormium tenax</i>	- flax
<i>Scirpus nodosus</i>	- scirpus
<i>S. cirrus</i>	- scirpus
<i>Carex virgata</i>	- carex
<i>Libertia ixiodes</i>	- NZ iris
<i>Thelymitra longifolia</i>	- orchid
<i>Deyeuxia billardieri</i>	- coastal deyeuxia
<i>Cortaderia richardii</i>	- toetoe
<i>Puccinella stricta</i>	- coastal grass

b) ADVENTIVES

<i>Dactylis glomerata</i>	- cocksfoot
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<i>Anthoxanthum odoratum</i>	- sweet vernal
<i>Lolium perrene</i>	- perennial ryegrass
<i>Agrostis tenuis</i>	- browntop
<i>A. stolonifera</i>	- creeping bent
<i>Juncus filicaulis</i>	- rush
<i>Cynosurus cristatus</i>	- cressed dogstail
<i>C. echinatus</i>	- rough dogstail
<i>Bromus mollis</i>	- soft brome
<i>B. unioloides</i>	- prairie grass
<i>B. tectorum</i>	- brome
<i>B. diandrus</i>	- ripgut brome
<i>Vulpia bromoides</i>	- vulpia
<i>Festuca rubra</i>	- red fescue
<i>Aira coryophyllea</i>	- hairgrass
<i>Holcus lanatus</i>	- Yorkshre fog
<i>Poa pratensis</i>	- poa pratensis
<i>Glyceria fluitans</i>	- floating sweetgrass
<i>Avena fatua</i>	- wild oats

HERBS

a) NATURAL

<i>Geranium sessiliflorum</i>	- geranium
<i>G. microphyllum</i>	- geranium
<i>G. solandri</i>	- geranium
<i>Gnaphalium audax</i>	- cudweed
<i>G. luteo - album</i>	- cudweed
<i>Dichondra repens</i>	- dichondra
<i>Wahlenbergia colensoi</i>	- wahlenbergia
<i>Disphyma australe</i>	- NZ ice plant
<i>Senecio wairauensis</i>	- senecio
<i>S. lautus</i>	- senecio
<i>S. quadridentatus</i>	- senecio
<i>Hydrocotyle moschata</i>	- hydrocotyle
<i>Oxalis exilis</i>	- oxalis
<i>Chenopodium allanii</i>	- NZ fathen
<i>C. ambiguum</i>	- NZ fathen
<i>Apium australe</i>	- apium
<i>Acaene novae - zelandiae</i>	- piripiri
<i>Aciphylla subflabellata</i>	- spaniard
<i>C. coronopifolia</i>	- cotula
<i>C. squalida</i>	- cotula
<i>Helichrysum filicaule</i>	- everlasting
<i>Rumex flexuosus</i>	- NZ dock

<i>Stellaria parviflora</i>	- stelaria
<i>Gingidia montana</i>	- anise
<i>Tillaea sieberiana</i>	- tillaea
<i>Epilobium billardierianum</i>	- willowherb
<i>Vittadinia australis</i>	- NZ vittadinia
<i>Convolvulus verecundus</i>	- NZ convolvulus
<i>Salomus repens</i>	- salomus
<i>Linum monogynum</i>	- linum
<i>Potamogeton</i> sp.	- pondweed
<i>Callatriche stagnalis</i>	- callatriche
<i>Montia fontana</i>	- montia
<i>Tetragonis trigyna</i>	- NZ spinach

b) ADVENTIVE

<i>Cerastium glomeratum</i>	- annual chickweed
<i>C. holosteioides</i>	- perennial chickweed
<i>Trifolium repens</i>	- white clover
<i>T. subterraneum</i>	- sub. clover
<i>T. dubium</i>	- suckling clover
<i>T. pratense</i>	- haresfoot trefoil
<i>T. tomentosum</i>	- wooly clover
<i>Monta perfoliata</i>	- miner's lettuce
<i>Cirsium arvense</i>	- Californian thistle
<i>C. vulgare</i>	- Scotch thistle
<i>Carduus tenuiflorus</i>	- winged thistle
<i>Silybum marianum</i>	- variegated thistle
<i>Sonchus oleraceus</i>	- sow thistle
<i>Sagina procumbens</i>	- pearlwort
<i>Bellis perennis</i>	- daisy
<i>Cardamine hirsuta</i>	- hoary cress
<i>Vicia sativa</i>	- vetch
<i>V. augustifolia</i>	- vetch
<i>Plantago lanceolata</i>	- plantain
<i>P. coronopsis</i>	- buckshorn plantain
<i>Verbascum thapsus</i> mullein	
<i>Spergularia media</i>	- sea spurrey
<i>Silene gallica</i>	- catchfly
<i>Polycarpon tetraphyllum</i>	- allseed
<i>Nasturtium officinale</i>	- water cress
<i>Medicago polymorpha</i>	- bur medick
<i>Lepidium ruderae</i>	- narrow leaved cress
<i>Fumaria muralis</i>	- scrambling fumitory
<i>Sisymbrium officinale</i>	- hedge mustard
<i>Crepis capillaris</i>	- hawksbeard

<i>Hypochaeris radicata</i>	- catsear
<i>Capsella bursa-pastoris</i>	- shepherd's purse
<i>Veronica arvensis</i>	- speedwell
<i>Geranium molle</i>	- dove's foot
<i>Stellaria media</i>	- chickweed
<i>Taraxicum officinale</i>	- dandelion
<i>Galium aparine</i>	- cleavers
<i>Vittadinia roba</i>	- Australian vittadinia
<i>Sedum acre</i>	- stonecrop
<i>Anagallis arvensis</i>	- scarlet pimpernel
<i>Reseda alba</i>	- mignonette
<i>Cereus</i> sp.	- cactus
<i>Mimulus guttatus</i>	- monkey musk
<i>Marrubium vulgare</i>	- horehound
<i>Urtica urens</i>	- nettle
<i>Stuartina muelleri</i>	- stuartina
<i>Erodium cicutarium</i>	- storksbill
<i>Anthriscus cucula</i>	- beaked parsley
<i>Arctotheca calendula</i>	- cape seed
<i>Aptena cordifolia</i>	- ice plant
<i>Centrathus ruber</i>	- valerian

FERNS

<i>Polystichum richardii</i>	- black shield fern
<i>Asplenium flabellifolium</i>	- necklace fern
<i>A. terrestre</i>	- ground spleenwort
<i>A. lucidum</i>	- shining spleenwort
<i>Pteridium aquilinum</i> [<i>esculentum</i>]	- bracken
<i>Pyrrosia serpens</i>	- leatherleaf
<i>Cheilanthes sieberi</i>	- rockfern
<i>Blechnum penna-marina</i>	- hard fern

Appendix 3

Land Birds (*asterix indicate introduced species)

Family	Representatives on Quail Island.
Accipitridae:	Harrier Hawk (<i>Circus approximans</i>)
Columbidae:	Rock Pigeon* (<i>Columa livia</i>)
Galliformes:	Californian Quail* (<i>Lophortyx californica</i>)
Strigidae:	Little Owl* (<i>Athene noctua</i>)
Alcedinidae:	Kingfisher (<i>Halcyon sancta</i>)
Alaudidae:	Skylark* (<i>Alauda arvensis</i>)
Hirundinidae:	Welcome swallow (<i>Hirundo neoxena</i>)
Muscicapidae:	Fantail (<i>Rhipidura fuliginosa</i>) , Grey warbler (<i>Gerygone igata</i>)
Turdidae:	Blackbird* (<i>Turdus merula</i>) Song thrush* (<i>Turdus philomelos</i>)
Prunellidae:	Hedgesparrow* (<i>Prunella modularis</i>)
Motacillidae:	Pipit (<i>Anthus novaezelandiae</i>)
Meliphagidae:	Bellbird (<i>Anthornis melanura</i>)
Zosteropidae:	Silvereye (<i>Zosterops lateralis</i>)
Fringillidae:	Chaffinch* (<i>Fringilla coelebs</i>), Goldfinch*, Greenfinch* (<i>Carduelis chloris</i>), Redpoll* (<i>Carduelis flammea</i>), Yellowhammer* (<i>Emberiza citrinella</i>)
Ploceidae:	House sparrow* (<i>Passer domesticus</i>)
Sturnidae:	Starling* (<i>Sturnus vulgaris</i>)
Cracticidae:	White backed magpie* (<i>Gymnorhina hypoleuca</i>)

Appendix 4

Results of Visitor Scoping

Visitors to the island were asked whether they supported the concept of ecologically restoring Quail Island. They were then asked to give a reason for their answer. Results revealed that 92% respondents said they supported the idea, while 6% did not and 2% did not know (Table 4.1). Half of the respondents supported the concept as they saw it as a means to contribute to the protection of nature, while 25% saw it as a way to improve the island. Others supported the concept because they believed it would be an asset for Christchurch (5%), enhance the enjoyment for children and families (5%) and that it would be a tourist attraction (2.5%). Reasons given for opposition to the concept were that the respondents preferred the island the way it was, and secondly that restoration should not go ahead at the expense of existing exotic trees.

Respondents were asked whether they would appreciate the island more less the same as before if it was restored. In order to gauge whether the visitors' appreciation for the island would increase if it was restored, respondents were asked what they liked and disliked. They were then asked if they would appreciate the island more, less or the same as before if it were forested. They were then asked whether they would visit the island more often if it were restored.

Results revealed that the most common "like" was the island's peacefulness and tranquility (40%). This was followed by its sheltered beaches (12.5%) followed by the feeling of being away (12.5%). Other reasons were the close proximity to Christchurch (5%), the ferry ride (5%), because it is an island (5%) and adventure for children (5%). Lesser responses were the island's natural state (2%), the openness (2%), and water skiing (2.5%) and the island's history (2.5%) (Table 4.2). The most frequently given "dislike" were noisy power boats 35%. Other frequent dislikes were the island's barrenness (16%), pines (16%). the dirty toilets (5%), lack of bbq and camping facilities (10%), followed by lack of rubbish bins (58%), crowds (2.5%) . Finally 20% of the visitors could think of nothing to dislike about the island (Table 4.3).

Visitors were then asked whether they would appreciate the island more, less or the same as before if it was covered in native forest. 82% said they would appreciate more, 6% said they

would appreciate it less, and 12% said they would appreciate it the same as before (Table 4.4)

Visitors were then asked whether they would be likely to visit the island more often if it was restored? 58% said they would visit the island more often if native bush was restored to the island, while 18% said they would not visit it more often and 24% did not know (Table 4.5).

Respondents were asked whether they would be willing to give a donation in support of the project and /or plant a tree as part of a community project. 17.5% said they would not do either/or. While 82.5 % said they would do either both (27.5%) or one (plant:25%) or the other(give a donation:12%). The results show that 82% of the respondents were either willing to donate their time, money or both to help a restoration project succeed.

Table 4.1

Q2) Support concept?	Number	%
Yes	37	92.5
No	2	5
Don't Know	1	2.5
Total	40	100

Table 4.2

Likes	Number	%
peacefulness	16	40
sheltered beaches	5	12.5
the feeling of being away	5	12.5
close proximity to Christchurch	2	5
history	1	2.5
ferry	2	5
islands	2	5
safety for children	2	5

adventure for children	2	5
water skiing	1	2.5
Don't know	1	2.5
Island's naturalness	1	2.5
openness	1	2.5
total	40	100

Table 4.3

Dislikes	Number	%
noisy power boats	14	35
Nothing	8	20
Pine trees	6	15
Barreness	3	7.5
No camping or bbq facilities	4	10
no rubbish bins	2	5
dirty toilets	2	5
crowds	1	2.5
Total	40	100

Table 4.4

Appreciation	Number	%
More	41	82
Less	3	6
same as before	6	12

Table 4.5

Visit More often?	Number	%
yes	29	58
no	9	18
don't know	12	24

**Ecological Restoration of Quail Island
Visitors Survey.**

- 1) Have you visited Quail Island before? yes/no
- 2) What do you **like** about Quail Island and why? (Please give the first answer that comes to mind).

- 3) What do you **dislike** about Quail Island and why? (Please give the first answer that comes to mind).

- 4) Would you support the idea of ecologically restoring Quail Island? This would mean re-establishing native forest and animals to the island.
yes/no
state your reasons:
- 5) If forest was restored to the island would you appreciate it more
less
same as before
state your reasons:
- 6) Would you visit the island more/less/same as before if the island was restored
- 7) Would you be prepared to a) give a donation yes/no
b) plant trees yes/no
c) either/or yes/no

Appendix 5

Maclean rabbit infestation scale. After Canterbury Regional Council (1996) p.13.

McLean Rabbit Infestation Scale	
1	No rabbits or sign seen
2	No rabbits seen, some sign noticeable
3	Odd rabbits seen, sign and some buck heaps showing up
4	Pockets of rabbits, sign and fresh burrows very noticeable
5	Infestation spreading out from heavy pockets
6	Infestation over whole area and increasing
7	Infestation heavy, rabbits moving in droves, pasture damage, warrens
8	Infestation at high level throughout, severe pasture and vegetation damage
9	Infestation almost at peak
10	Maximum level, rabbits must spread out over wide area or starve.